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Radiological Health Data

VOLUME II, NUMBER 9

SEPTEMBER 1961

Monthly Report

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Except where material is directly quoted or otherwise credited, summaries and abstracts are prepared by the staff of the Data Collation and Analysis Unit, Division of Radiological Health. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

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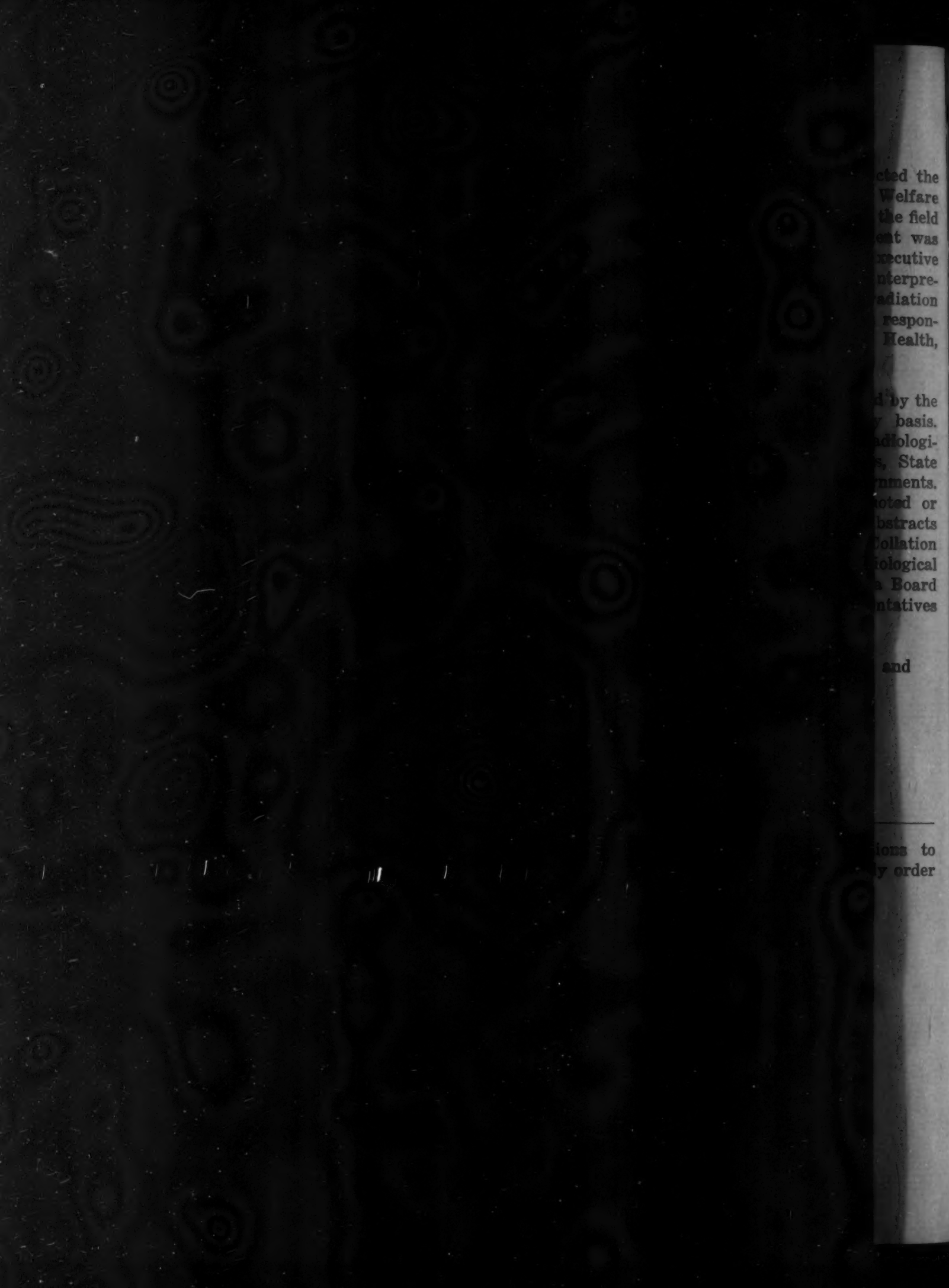

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SECTION I. — AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. Although no nuclear tests have been conducted by the United States since 1958, the program has proved sufficiently valuable that it has been extended to a year-round basis. Currently, it consists of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 of the stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The station located at Atlanta, Georgia, conducts its own analyses.

Air samplers are in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a cellulose carbon-loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples. About 85 percent of the stations collect samples of precipitation which are sent to Washington, D.C., for analysis. Values are now below limits of detection by present instrumentation.

Table 1 summarizes the data for April 1961.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR-GROSS BETA DETERMINATIONS, APRIL 1961

Station location	Number of samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average ($\mu\mu c/m^3$)	Station location	Number of samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average [1] ($\mu\mu c/m^3$)
Anchorage, Alaska	19	0.14	<0.10	<0.10	Minneapolis, Minn	8	0.15	<0.10	<0.11
Fairbanks, Alaska	20	0.18	<0.10	<0.11	Pascagoula, Miss	19	0.27	<0.10	<0.16
Juneau, Alaska	17	0.14	<0.10	<0.11	Jefferson City, Mo	19	0.21	<0.10	<0.12
Phoenix, Ariz	4	0.26	<0.10	<0.19	Helena, Mont	20	0.25	<0.10	<0.13
Little Rock, Ark	20	0.26	<0.10	<0.14	Trenton, N. J	18	0.30	<0.10	<0.13
Berkeley, Calif	20	0.24	<0.10	<0.12	Santa Fe, N. Mex	16	0.40	<0.10	<0.20
Los Angeles, Calif	19	0.17	<0.10	<0.13	Albany, N. Y	27	0.15	<0.10	<0.10
Denver, Colo	16	0.16	<0.10	<0.12	Gastonia, N. C	18	0.20	<0.10	<0.14
Hartford, Conn	26	0.23	<0.10	<0.11	Oklahoma City, Okla	16	0.20	<0.10	<0.14
District of Columbia	23	0.24	<0.10	<0.12	Ponca City, Okla	29	0.20	<0.10	<0.11
Jacksonville, Fla	19	0.22	<0.10	<0.13	Portland, Oreg	19	0.25	<0.10	<0.14
Atlanta, Ga	11	0.30	<0.10	<0.12	Harrisburg, Pa	12	0.15	<0.10	<0.12
Honolulu, Hawaii	20	0.17	<0.10	<0.10	Providence, R. I	20	0.23	<0.10	<0.12
Boise, Idaho	6	0.19	<0.10	<0.14	Columbia, S. C	6	0.16	<0.10	<0.14
Springfield, Ill	8	0.14	<0.10	<0.11	Pierre, S. Dak	5	0.20	<0.10	<0.12
Indianapolis, Ind	30	0.16	<0.10	<0.11	Austin, Tex	19	0.23	<0.10	<0.14
Iowa City, Iowa	19	0.19	<0.10	<0.13	El Paso, Tex	15	0.50	0.17	0.30
Topeka, Kans	20	0.20	<0.10	<0.12	Salt Lake City, Utah	30	0.20	<0.10	<0.12
New Orleans, La	2	0.10	<0.10	<0.10	Richmond, Va	19	0.16	<0.10	<0.11
Baltimore, Md	20	0.19	<0.10	<0.12	Seattle, Wash	20	0.11	<0.10	<0.10
Lawrence, Mass	18	0.11	<0.10	<0.10	Madison, Wis	30	0.20	<0.10	<0.11
Lansing, Mich	30	0.21	<0.10	<0.12	Cheyenne, Wyo	8	0.13	<0.10	<0.11

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

Surface Air Radon, Thoron and Fission Product Gross Beta Concentrations At Cincinnati, Ohio

Robert A. Taft Sanitary Engineering Center, Public Health Service

Natural background radioactivity in our atmosphere is an important public health consideration because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Natural radioactivity in surface air is due to a number of unstable nuclides other than those produced by man. The earth's crust contains trace amounts of uranium and thorium that occur naturally and which decay through a series of their daughter products. These decay products of uranium and thorium are introduced into surface air through their rare gas daughters, radon (radon-222) and thoron (radon-220), which in turn continue to decay through the uranium and thorium series, respectively. The radon and thoron content of air depends on the escape of these rare radioactive gases from the earth. Concentrations depend on prevailing atmospheric conditions such as ambient temperature, humidity, and pressure and on soil conditions such as moisture, porosity, and temperature.

Most of the natural radioactivity in surface air is due to radon (Rn^{222}) and its daughters. Thoron (Rn^{220}) and its daughters contribute much less because of thoron's short half-life and hence, a lower diffusion rate from the soil.

The Radiological Health Research Activities, Research Branch, Division of Radiological Health, Public Health Service, performs a continuous daily sampling program for radon (Rn^{222}) thoron (Rn^{220}), and gross beta fission product concentrations in surface air. The gross beta activity of atmospheric particulates, when measured several days after sample collection, is principally due to artificially produced radionuclides.

Air is filtered through a membrane filter, and the daughter products of radon and thoron, which are particulates, are deposited on the filter. Measurements of the alpha activity on the filter are related to the concentrations of radon or thoron in surface air. Most of the activity of radon daughters, that have a composite half-life of approximately 0.5 hour, would decay to 0.5 per cent of the original value in less than four hours. The activity of thoron daughters that have a composite half-life of 10.6 hours, would decay to 0.5 per cent of its original value in about four days. For this reason the gross beta determinations are made at least four days after the end of each sampling period.

There has been a recent change in the reporting period because the data is now computed by an electronic data processing system, which is programmed for thirteen four-week periods per calendar year.

The data for the period March 27-May 19, 1961 are presented in table 1.

TABLE 1.—RADON, THORON, AND FISSION PRODUCT GROSS BETA CONCENTRATIONS, MARCH 27–MAY 19, 1961

End of sampling period	Continuous sample collection			Radon[a] a.m. ($\mu\mu c/m^3$)	Radon-thoron[b] p.m. ($\mu\mu c/m^3$)	Thoron[c] ($\mu\mu c/m^3$)	Beta[d] activity ($\mu\mu c/m^3$)	End of sampling period	Continuous sample collection			Radon[e] a.m. ($\mu\mu c/m^3$)	Radon-thoron[f] p.m. ($\mu\mu c/m^3$)	Thoron[g] ($\mu\mu c/m^3$)	Beta[h] activity ($\mu\mu c/m^3$)
	Sample change time	Sample period (hours)	Volume (m^3)						Sample change time	Sample period (hours)	Volume (m^3)				
Mar. 27	0819	71.9	71.1	290	90	3.4	0.07	Apr. 24	0810	72.0	84.0	180	100	1.8	0.09
28	0810	23.8	29.1	190	70	1.5	0.11	25	0802	23.9	28.3	90	50	1.2	0.21
29	0803	23.9	30.4	110	120	1.3	0.00	26	0816	24.2	29.0	90	80	0.7	0.00
30	0800	23.9	29.8	100	90	1.3	0.04	27	0815	23.9	29.1	140	60	1.6	0.07
31	0812	23.6	30.5	180	40	1.3	0.08	28	0806	23.7	28.3	130	50	1.9	0.13
Apr. 3	0805	71.9	89.6	340	170	3.1	0.10	May 1	0814	72.1	86.1	300	60	3.8	0.10
4	0803	24.0	29.2	150	100	1.3	0.11	2	0807	23.9	28.4	250	100	2.3	0.14
5	0810	24.1	29.3	360	40	5.2	0.10	3	0813	24.1	28.6	590	30	4.5	0.16
6	0804	23.9	28.9	120	110	2.0	0.08	4	0815	24.0	28.7	540	50	5.4	0.11
7	0801	23.9	29.4	190	90	3.1	0.54	5	0828	24.1	29.0	160	40	2.6	0.09
10	0805	72.1	87.4	100	80	1.4	0.04	8	0815	71.8	85.9	70	160	0.4	0.00
11	0808	24.0	28.5	210	50	1.7	0.01	9	0803	23.8	28.6	50	90	0.1	0.16
12	0813	24.1	28.0	80	30	0.9	0.10	10	0805	24.0	28.9	90	80	0.6	0.12
13	0815	24.0	27.8	60	70	0.7	0.08	11	0806	24.0	29.3	70	50	0.9	0.12
14	0807	23.8	28.0	160	30	1.6	0.01	12	0810	24.0	29.1	150	90	1.3	0.13
17	0800	71.9	85.5	80	50	1.2	0.08	15	0800	63.8	76.9	100	60	2.8	0.15
18	0811	24.2	28.9	110	80	0.9	0.10	16	0815	24.1	28.5	90	90	1.2	0.03
19	0800	23.8	28.9	390	50	1.9	0.02	17	0800	23.7	28.7	160	50	2.4	0.06
20	0810	24.2	29.5	220	60	1.5	0.12	18	0810	24.1	29.0	160	50	0.2	0.17
21	0810	24.0	29.2	120	70	1.5	0.08	19	0810	24.0	29.2	220	140	2.1	0.13
Average				178	74	1.8	0.09	Average				180	74	1.9	0.11

[a] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72 hours) has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 16 and ± 33 $\mu\mu c/m^3$.

[b] Radon-thoron concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one working day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 10 and ± 22 $\mu\mu c/m^3$.

[c] Thoron concentrations are derived from alpha measurements referred to in footnote (a) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the standard deviation (2σ) falls between ± 0.3 and ± 0.7 $\mu\mu c/m^3$.

[d] Surface air fission product gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours). Twice the standard deviation (2σ) falls between ± 0.01 and ± 0.05 $\mu\mu c/m^3$.

[e] Radon concentrations are derived from alpha measurements determined immediately after the sampling period (24 to 72) hours has ceased. Reported radon concentrations have been corrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 12 and ± 43 $\mu\mu c/m^3$.

[f] Radon-thoron concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. Therefore, the reported values were actually determined one working day prior to the date reported here. Reported radon concentrations are uncorrected for any thoron daughter interferences. Twice the standard deviation (2σ) falls between ± 10 and ± 22 $\mu\mu c/m^3$.

[g] Thoron concentrations are derived from alpha measurements referred to in footnote (e) but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder. Twice the stardard deviation (2σ) falls between ± 0.2 and ± 0.8 $\mu\mu c/m^3$.

[h] Surface air fission product gross beta concentrations are based on measurements made at least 4 days after the end of each sampling period (24 to 72 hours. Twice the standard deviation (2σ) falls between ± 0.01 and ± 0.05 $\mu\mu c/m^3$.

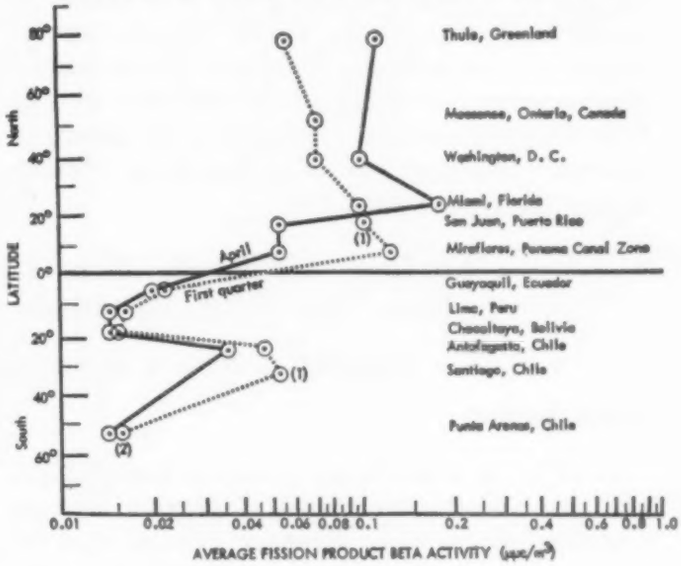
Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during April 1961 is presented in table 1, and the radioactivity profile for the same month and the first quarter 1961 are shown in figure 1. This figure illustrates the data plotted in semilogarithmic coordinates. The ordinate is expressed in micromicrocuries per cubic meter of surface air. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

FIGURE 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), FIRST QUARTER AND APRIL 1961



(1) Average based on one month.
(2) Average based on two months.

TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION, APRIL 1961

[Disintegrations per minute/cubic meter]

Day	Punta Arenas, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	San Juan, Puerto Rico	Mauna Loa, Hawaii	Miami, Florida	Washington, D.C.	Thule, Greenland
1	0.02	0.06	0.01	0.02	0.05	0.06	----------	0.18	0.30	0.26	0.25
2	0.02	0.06	0.01	0.02	0.04	0.06	----------	0.18	0.30	0.26	0.25
3	0.02	0.06	0.01	0.02	0.06	0.06	----------	0.18	0.30	0.26	0.25
4	0.02	----------	0.05	0.04	0.05	0.06	----------	0.25	0.47	0.19	0.08
5	0.02	----------	0.05	0.04	0.03	0.06	----------	0.25	0.47	0.19	0.08
6	0.02	0.05	0.03	0.04	0.04	0.12	----------	0.14	0.55	0.17	0.20
7	0.02	0.05	0.03	0.04	0.04	0.12	----------	0.14	0.55	0.17	0.20
8	0.02	0.16	0.03	0.04	0.05	0.13	----------	0.06	0.29	0.19	0.31
9	0.02	0.16	0.03	0.04	0.07	0.13	----------	0.06	0.29	0.19	0.31
10	0.02	0.16	0.03	0.04	0.11	0.13	0.08	0.06	0.29	0.19	0.17
11	0.03	0.04	0.05	0.03	0.03	0.14	0.08	0.06	0.24	0.08	0.17
12	0.03	0.04	0.05	0.03	0.05	0.14	0.08	0.06	0.24	0.08	0.17
13	0.03	0.07	0.02	0.03	0.05	0.12	0.16	0.28	0.28	0.10	0.43
14	0.03	0.07	0.02	0.03	0.05	0.12	0.16	0.28	0.28	0.10	0.43
15	0.04	0.07	0.01	0.01	0.04	0.14	0.09	0.13	0.24	0.31	0.34
16	0.04	0.07	0.01	0.01	0.06	0.14	0.09	0.13	0.24	0.31	0.34
17	0.04	0.07	0.01	0.01	0.03	0.14	0.09	0.13	0.24	0.31	0.34
18	0.06	0.05	0.02	0.05	0.03	0.15	0.11	0.12	0.47	0.18	0.22
19	0.06	0.05	0.02	0.05	0.03	0.15	0.11	0.12	0.47	0.18	0.22
20	0.06	0.05	0.04	0.02	0.03	0.14	0.13	0.13	0.46	0.22	0.21
21	0.06	0.05	0.04	0.02	0.03	0.14	0.13	0.13	0.46	0.22	0.21
22	0.03	0.07	0.03	0.03	0.05	0.11	0.12	0.39	0.53	0.22	0.33
23	0.03	0.07	0.03	0.03	0.04	0.11	0.12	0.39	0.53	0.22	0.33
24	0.03	0.07	0.03	0.03	0.04	0.11	0.12	0.39	0.53	0.22	0.33
25	----------	0.07	0.02	0.06	0.08	0.12	0.16	0.33	0.63	0.45	0.26
26	----------	0.07	0.02	0.06	0.05	0.12	0.16	0.33	0.63	0.45	0.26
27	----------	0.09	0.07	0.03	0.04	0.12	0.05	0.39	0.50	0.28	0.30
28	----------	0.09	0.07	0.03	0.06	0.12	0.05	0.39	0.50	0.28	0.30
29	----------	0.10	0.03	0.04	0.05	0.11	0.21	0.12	0.48	0.29	0.23
30	----------	0.10	0.03	0.04	0.05	0.11	0.21	0.12	0.48	0.29	0.23
Mean (dpm/m³)	0.03	0.08	0.03	0.03	0.05	0.12	0.12	0.20	0.41	0.23	0.26
Mean (μμc/m³)	0.014	0.034	0.014	0.014	0.022	0.054	0.054	0.090	0.185	0.104	0.117

SAMPLING PROGRAMS FOR RADIOACTIVITY IN AIR

The following article is the second in a series of discussions intended to present summaries of atmospheric levels of radioactivity. The first article, which appeared in *Radiological Health Data*, Vol. II, No. 8, summarized the results of surface air fission product gross beta measurements conducted by the Public Health Service Radiation Surveillance Network. This discussion summarizes similar data collected by the U.S. Naval Research Laboratory at carefully selected sites near the 80th meridian (West) during the period 1958-1960.

The presentation and illustrations were compiled by Messrs. Roscoe H. Goeke, John G. Bailey, and Andreas P. Zizos of the Data Collation and Analysis Unit, Division of Radiological Health, Public Health Service. The authors wish to express their appreciation to Dr. Luther B. Lockhart, Jr. of the U.S. Naval Research Laboratory for supplying the basic data and assistance in preparing this presentation, and to the staff of the Atmospheric Radioactivity Research Project, U.S. Weather Bureau, for their review of the text.

Surface Air Gross Beta Fission Product Concentrations Near The 80th Meridian (West) During 1958-1960

Compiled by Division of Radiological Health, Public Health Service

Introduction

In 1956 the U.S. Naval Research Laboratory, with the assistance of the U.S. Atomic Energy Commission, the U.S. Weather Bureau, and interested groups in Canada and South America, initiated a program for measuring the fission product radioactivity in air at a carefully selected group of sites near the 80th meridian. During 1957, this program was expanded to include collections at several other locations which were of interest to the U.S. Air Force Cambridge Research Center. In 1958, this work was carried out as part of the International Geophysical Year Program on Atmospheric Nuclear Radiation. Sampling continued during 1959 as part of the International Geophysical Cooperation-1959 Program. The Network continued operations during 1960 with a reduction in the number of collection sites. The program has been partially financed since 1956 by the Division of Biology and Medicine, U.S. Atomic Energy Commission.

All gross beta samples from a given station were combined at the end of each month, and radiochemical analyses were conducted for Sr^{89}, Sr^{90}, Y^{91}, Cs^{137}, Ce^{141}, Ce^{144}, and occasionally for Pb^{210}. In 1958, the analytical scheme was modified so the W^{185} could be isolated from the samples. Subsequently, analyses for Pb^{210} were discontinued because the W^{185} procedure interfered with the recovery of Pb^{210}.

Figure 1 illustrates the geographic distribution of the collecting sites, and table 1 presents their respective coordinates, elevation, sampling frequency, and operating agency.

FIGURE 1.—ATMOSPHERIC RADIOACTIVITY STATIONS NEAR THE 80TH MERIDIAN *(5)*

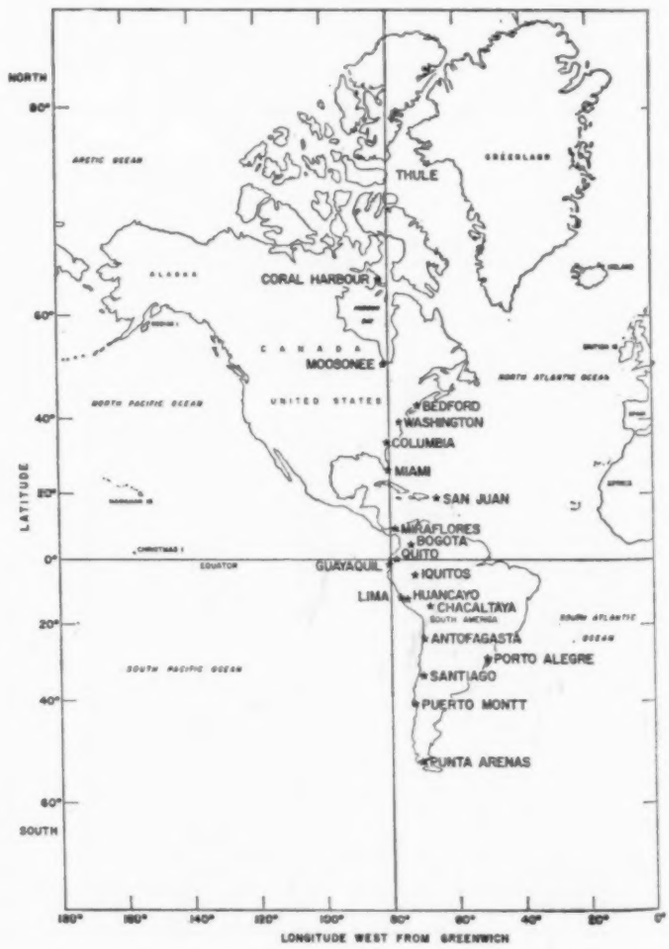


TABLE 1.—COLLECTING SITES ASSOCIATED WITH THE NRL/IGY PROGRAM OF ATMOSPHERIC NUCLEAR RADIATION*(5)*

Station	Latitude	Longitude	Elevation (m)	Operator
Daily Filter Collections				
Thule, Greenland	76°35′N	68°35′W	259	IGY Thule Coordinator, U.S. Air Force
Coral Harbour, N.W.T., Canada	64°12′N	83°22′W	59	Meteorological Branch, Department of Transport (Canada)
Moosonee, Ontario, Canada	51°16′N	80°39′W	10	Meteorological Branch, Department of Transport (Canada)
Bedford, Mass., USA	42°27′N	71°22′W	80	USAF Cambridge Research Center
Silver Hill, Maryland, USA (Washington, D.C.)	38°50′N	76°57′W	88	U.S. Weather Bureau
Columbia, S.C., USA	33°57′N	81°07′W	69	U.S. Weather Bureau
Miami, Florida, USA	25°49′N	80°17′W	4	U.S. Weather Bureau
San Juan, Puerto Rico	18°26′N	66°00′W	10	U.S. Weather Bureau
Miraflores, Panama Canal Zone	9°00′N	79°35′W	10	Canal Zone Corrosion Laboratory, U.S. Naval Research Laboratory
Bogota, Colombia	4°37′N	74°04′W	2640	Instituto Geofisico de los Andes Colombianos
Quito, Ecuador	0°08′S	78°26′W	2818	Astronomic Observatory
Guayaquil, Ecuador	2°10′S	79°52′W	7	Meteorological Office
Iquitos, Peru	3°45′S	73°11′W	117	Corporacion Peruana de Aeropuertos y Aviacion Comercial (CORPAC)
Lima, Peru	12°06′S	77°01′W	134	Corporacion Peruana de Aeropuertos y Aviacion Comercial (CORPAC)
Huancayo, Peru	12°07′S	75°20′W	3353	Instituto Geofisico de Huancayo
Chacaltaya, Bolivia	17°10′S	68°15′W	5220	Universidad Mayor de San Andres, Laboratorio de Fisica Cosmica de Chacaltaya
Antofagasta, Chile	23°37′S	70°16′W	519	NASA Satellite Tracking Station
Porto Alegre, Brazil	30°02′S	51°13′W	24	Servico de Meteorologia
Santiago, Chile	33°27′S	70°42′W	520	Oficina Meteorologica de Chile
Puerto Montt, Chile	41°27′S	72°57′W	5	U.S. Weather Bureau
Punta Arenas, Chile	53°08′S	70°53′W	3	Oficina Meteorologica de Chile
Weekly Filter Collections				
Drifting Station Alpha [1]	83°–86°N	110°–180°W	3	U.S. Weather Bureau/IGY
Muana Loa, Hawaii, Hawaii	19°28′N	155°36′W	3394	U.S. Weather Bureau/IGY
Pearl Harbor, Oahu, Hawaii	21°22′N	157°58′W	5	U.S. Naval Air Station, Ford Island
Subic Bay, Philippines	14°49′N	120°17′E	18	U.S. Naval Station, Subic Bay

[1] Station evacuated November 1, 1958.

Summary of Results, 1958-1960

Figure 2 presents quarterly profiles of surface air fission product gross beta measurements conducted at stations near the 80th meridian (West). The basic data used in preparing this illustration was supplied by the U.S. Naval Research Laboratory. Starting with the first quarter of 1958, and proceeding to the second quarter of that year, one finds an overall increase in the atmospheric concentrations for both the Northern and Southern Hemispheres, but the third quarter's data indicate an unusual condition. In this case, the Northern Hemisphere's peak has decreased somewhat, while the Southern Hemisphere's peak exceeds that of the Northern Hemisphere for the first and only time. During the last quarter of 1958, the Northern Hemisphere's profile appears to be somewhat similar to the one shown for the second quarter of that year, and the Southern Hemisphere's profile appears to have decreased to a level between the ones shown for the second and third quarters of that year.

In the first and second quarters of 1959, the Northern Hemisphere's profiles exemplify the highest maxima since the conception of this network in 1956. The Southern Hemisphere's profile for the first quarter has exceeded that for the same period in 1958, while its profile during the second quarter is below that for the corresponding period of the previous year. Notice that during the third and fourth quarters of 1959, both the Northern and Southern Hemispheres show a drastic reduction in their ground-level concentration when compared to the profiles for the second quarter of 1959 and the third and fourth quarters of 1958.

During the first quarter of 1960 there appears a rather marked rise between 0° and 20° latitude (North), and a situation for the Southern Hemisphere which is not very dissimilar to the one which occurs during the fourth quarter of 1959. During the second, third, and fourth quarters of 1960, the Northern Hemisphere exemplifies a gradual decrease, while the Southern Hemisphere does not change markedly. In fact, the maxima for both the Northern and Southern Hemispheres are approximately the same.

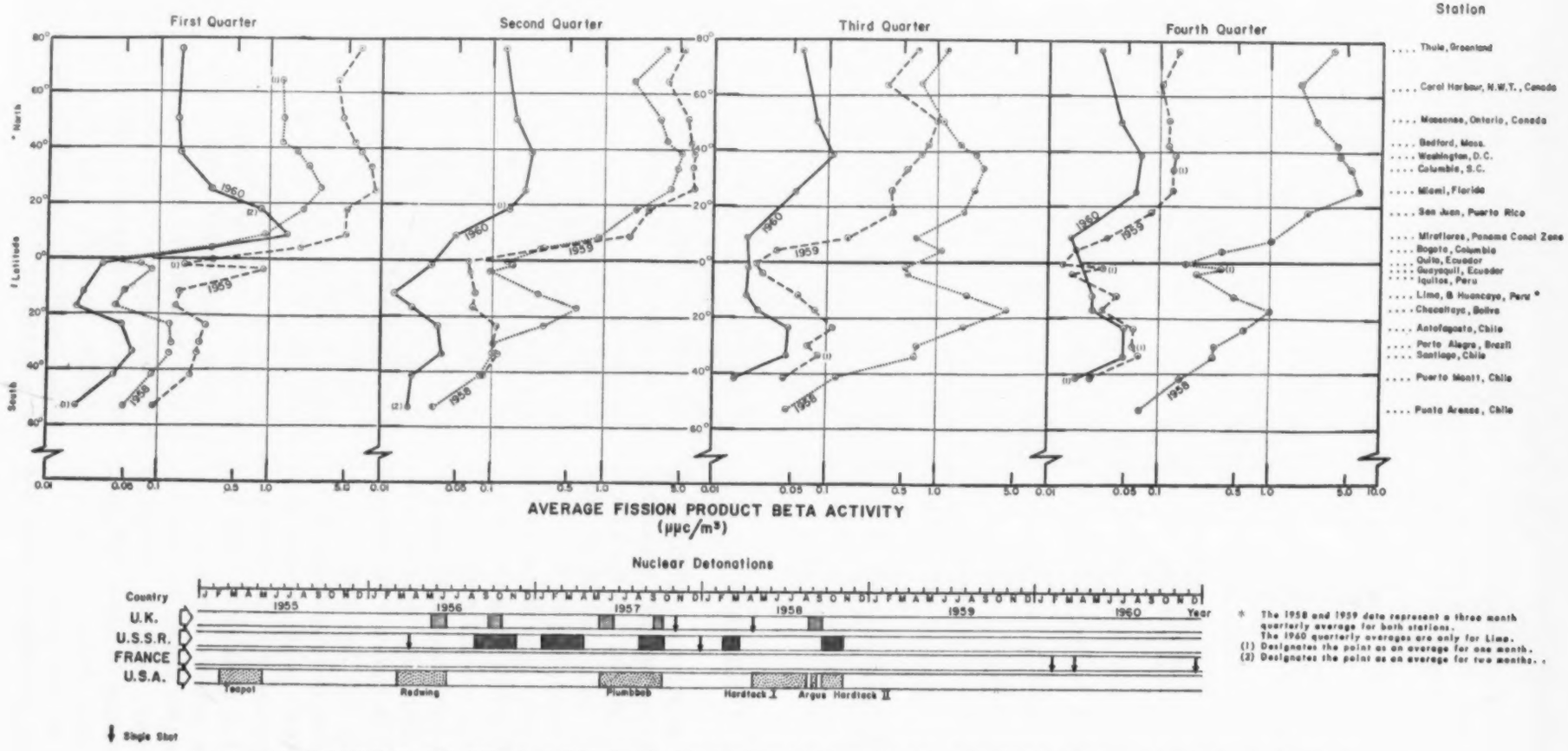


FIGURE 2.—PROFILE OF BETA ACTIVITY, QUARTERLY RESULTS OF SURFACE AIR MEASUREMENTS CONDUCTED AT STATIONS NEAR THE 80TH MERIDIAN

The effects of nuclear tests are readily noted by increases in surface air fission product gross beta concentrations in the Northern Hemisphere during the Soviet tests of February and March 1958, whose effects lasted well into June, and the Soviet tests from 30 September through 3 November 1958, where the effects were strong throughout the remainder of 1958 and well into 1959. Neither of the United States' test series of 1958 had a relatively large effect on this hemisphere, although the presence of debris from the Pacific tests of April-July (Operation Hardtack, Phase I) were detected through the W^{185} isotope produced in this series of tests as a tracer (7). During January-April 1958, no tests occurred south of the Equator. Therefore, low activities were encountered in spite of the high activities prevalent in the Northern Hemisphere. The Southern peak starting to form in the second quarter of 1958 may have been due, in part, to the April United Kingdom detonation at Christmas Island, although large amounts of the W^{185} tracer identified a considerable portion of this activity as debris arising from the United States Pacific tests (7). Radiochemical data, not presented here, may help to explain the unusual situation noted in the Southern Hemisphere during the third quarter of 1958 (7). These data have indicated that at least two bulk exchanges of air between hemispheres occurred during May-July 1958. It appears likely that this new debris was transported by upper tropospheric winds during the Hardtack series in the Pacific (1958).

During 1959, no fresh debris was added to the atmosphere. The maxima which appear in the Northern Hemisphere during the first and second quarters of that year are undoubtedly attributable primarily to the fall 1958 USSR series. Monthly fission product gross beta measurements conducted in the Northern Hemisphere indicate sudden drops after May 1959 with a maximum residence time of 30 days for tropospheric debris. These conclusions are confirmed by the radio-chemical data (3).

The large peak between 0° and 20° latitude (North) during the first quarter of 1960 is, without question, due to the French detonation on 13 February. The second French detonation of 1 April is not easily seen in the second quarter's data. This is due to the small yield of this device and to the fact that the background of radioactivity had risen as a result of the seasonal increase in stratospheric deposition. Note that with the exception of that region between approximately 0° and 10° latitude (South), the Southern Hemispheric profiles have not changed considerably.

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(2) Joint Committee on Atomic Energy, Congressional Hearings on Radioactive Fallout, 1957, 1959.

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(4) L. B. Lockhart, Jr., R. A. Baus, R. L. Patterson, Jr., and A. W. Saunders, Jr., "Radiochemical Analyses of Air Filter Samples Collected During 1958," NRL Report 5390, 1 October 1959.

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(11) NRL Monthly letters Reports "Fission Product Radioactivity of the Air Along the 80th Meridian (West)," (1956-Continuing).

(12) Radioactivity Data Sheets forwarded monthly to IGY World Data Center, Asheville, N. C., 1958-1959.

(13) R. A. Baus, R. L. Patterson, Jr., A. W. Saunders, Jr., and L. B. Lockhart, Jr., "Radiochemical Analyses of Air Filter Samples Collected During 1957," NRL Report 5239, December 1958.

SECTION II. — FOOD, OTHER THAN MILK

Survey of Radioactivity in Food

Food and Drug Administration

The following tabulations present the results of a continuing surveillance of food items, conducted by the Food and Drug Administration (FDA). The FDA's 18 Districts throughout the United States collect and analyze all samples for strontium-90. The following data are the results of analyses conducted on approximately 1500 samples comprising 50 different foods collected in 1960. Table 1 gives results on 6 different vegetables, table 2, the results on 3 different fruits, and table 3, the results on wheat and its derivatives. A trend toward lower concentrations of strontium-90 in fruits, as compared with vegetables, is indicated.

TABLE 1.—STRONTIUM-90 CONTENT OF VEGETABLES, 1960

[Concentration in $\mu\mu c$/kg original material]

Food item	Harvest Date	Area		Strontium-90
		County	State	
Cabbage	September 28	Wayne	N.Y.	19.7
Cabbage	October 10	Madison	Ill.	7.1
Cabbage	25	Ada & Canyon	Idaho	2.0
Celery	September 1	Monterey	Calif.	0.9
Celery	27	Wayne	N.Y.	2.1
Celery	27	Wayne	N.Y.	2.4
Celery	28	Cayuga	N.Y.	1.8
Green beans (canned).	November 16	Hidalgo	Tex.	1.0
Green beans (canned).	16	Hidalgo	Tex.	0.8
Lettuce	August 29	Rio Grande	Colo.	4.0
Lettuce	29	Saquache	Colo.	2.4
Lettuce	30	Alamosa	Colo.	3.5
Lettuce	September 14	Oswego	N.Y.	2.2
Lettuce	21	Oswego	N.Y.	1.1
Lettuce	21	Oswego	N.Y.	5.4
Lettuce	21	Oswego	N.Y.	2.6
Lettuce	22	Oswego	N.Y.	4.5
Lettuce	26	Hamilton	Ohio	5.9
Lettuce	October 8	Marion	Ohio	8.2
Potatoes	August 9	Wayne	N.Y.	4.7
Potatoes	October 3	Canyon	Idaho	1.2
Spinach	4	Genesee	N.Y.	2.9
Spinach (fresh)	4	Wayne	N.Y.	4.4
Spinach (frozen)	4	Wayne	N.Y.	6.7
Spinach	18	Yates	N.Y.	4.0

TABLE 2.—STRONTIUM-90 CONTENT OF FRUITS, 1960

[Concentration in $\mu\mu c$/kg original material]

Food item	Harvest date	Area		Strontium-90
		County	State	
Apples, pulp	September 27	Doniphan	Kans.	0.9
Apples, pulp	27	Lehigh	Pa.	1.8
Apples, pulp	October 6	York	Pa.	1.3
Apples, whole	5	Berks	Pa.	1.0
Apples, whole	7	Washington	Md.	1.0
Apples, whole	20	Utah	Utah	0.6
Peaches, whole	August	Niagara	N.Y.	1.1
Tomatoes, canned	September 19	Niagara	N.Y.	0.9
Tomatoes, canned [1]	23	Chautaugna	N.Y.	0.6
Tomatoes, canned [2]	October 3	Orleans	N.Y.	0.9
Tomatoes, fresh	September 23	Chataqua	N.Y.	1.0
Tomatoes, fresh	October 3	Orleans	N.Y.	1.6

[1] Peeled and canned from fresh Chataqua tomatoes.
[2] Peeled and canned from fresh Orleans tomatoes.

TABLE 3.—STRONTIUM-90 CONTENT OF WHEAT AND DERIVATIVES

[Concentration in μμc/kg original material]

Food item	Harvest date	Area		Strontium-90
		County	State	
Bran [1]	July 1960	Salano & Moduc	Calif.	13
Bran [2]	July 1960	Anderson & Aconee	S.C.	64
Bran [2]	July 1960	Anderson & Aconee	S.C.	47
Flour [2]	July 1960	Anderson & Aconee	S.C.	6
Wheat	Fall, 1959	Morrow	Oreg.	3.5
Wheat	Fall, 1959	Franklin	Wash.	1.5
Wheat	Fall, 1959	Walla Walla	Wash.	8.1
Wheat	Fall, 1959	Gallatin	Mont.	21
Wheat	Fall, 1959	Pondera	Mont.	18
Wheat	Fall, 1959	Fergus	Mont.	11
Wheat	Fall, 1959	Hill	Mont.	12
Wheat	Fall, 1959	Chotean	Mont.	54
Wheat	June 20, 1960	Solano	Calif.	1.8
Wheat	July 1960	Modoc	Calif.	1.5
Wheat	July 1960	Anderson & Aconee	S.C.	48
Wheat	August 9, 1960	Carver	Minn.	10

[1] Sample prepared from Salano and Moduc wheats.
[2] Sample prepared from Anderson and Aconee wheats.

Estimate Of The Dietary Intake Of Radium-226 For New York City Infants [1]

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U.S. Atomic Energy Commission

For the purpose of estimating the strontium-90 dietary intake of infants in New York City, the Health and Safety Laboratory began a special study in August 1959 to sample and analyze periodically, commercially processed baby foods and milks for strontium-90 and calcium. Results of three semi-annual samplings, as well as a discussion of sample selection and consumption figures, have been reported in previous quarterly reports (1, 2).

The samples collected in August of 1960 were assayed for radium-226, employing the barium chromate fractions obtained during the strontium-90 analysis and the radon-222 emanation method (3). It was assumed that the recovery values determined by strontium-85, could be applied to the radium results. Four blank reagent samples were prepared by running distilled water through the actual sample procedure. The average amount of radium found in the blanks was 0.01 μμc. The lowest amount detected in the food samples was 0.26 μμc. Two emanations and countings performed on each of seven barium chromate solutions, derived from these samples, indicated an average precision of 95 percent for this part of the procedure.

The radium-226, and previously reported calcium data, are presented in table 1. If the assumption is made that the August 1960 radium-226 values are typical, then we calculate the total radium-226 intake of an infant during the first year to be 212 μμc. The radium-226 to calcium ratio of the infant's diet would be 0.65 μμc per gram.

[1] Reported in *Quarterly Summary Report*, HASL-113, July 1, 1961.

REFERENCES

(1) *Quarterly Summary Report*, HASL-88, July 1, 1960.
(2) *Quarterly Summary Report*, HASL-111, April 1, 1961.
(3) Described in *Quarterly Summary Report*, HASL-113, July 1, 1961, p. 90.

TABLE 1.—RADIUM-226 AND CALCIUM IN THE DIET OF AN INFANT FOR HIS FIRST YEAR OF LIFE

[Based on foods sampled in August 1960]

Type of food	Quantities consumed (kg)	Radium-226			Total consumed	
		gmCa/kg original material	μμc/kg original material	μμc/gm Ca	Ra 226 (μμc)	Calcium (gm)
Cereals	8	8.22	14.3	1.7	114	66
Vegetables	23	0.29	0.59	2.0	14	7
Fruits	23	0.08	0.44	5.5	10	2
Meats	17	0.12	0.43	3.6	7	2
Subtotal: Non-milk fraction of diet				1.9	145	77
Milks:						
Formula	37	0.95	0.39	0.41	14	35
Evaporated	137	1.56	0.39	0.25	53	214
Subtotal: Milk fraction of diet				0.27	67	249
Total: Combined milk and non-milk fractions				0.65	212	326

Strontium-90 Concentration In Bread In New York City

Health and Safety Laboratory, U.S. Atomic Energy Commission

The following table presents data on strontium-90 concentrations in bread purchased in New York City during October 1960 through January 1961. One loaf of each type was purchased daily from a local grocer and the loaves were composited on a monthly basis. Five brands were represented in each month's sample. Daily sampling of bread for monthly compositing was discontinued after January 1961. Instead, bread samples will be obtained at the same time the quarterly sampling is made in New York City for the 19 food categories listed in Tri-City Diet Study.

Previous results were reported in *Radiological Health Data*, Volume I, Numbers 7 and 9, and Volume II, Numbers 4 and 6.

TABLE 1.—STRONTIUM-90 AND CALCIUM IN BREAD PURCHASED IN NEW YORK CITY, OCTOBER 1960-JANUARY 1961[1]

Month	Calcium		Strontium-9					
	gm/kg of original material		μμc/kg of original material		μμc/gm Ca		μμc daily intake[3]	
	Whole-wheat	White	Whole-wheat	White	Whole-wheat	White	Whole-wheat	White
October 1960	0.69	0.63	17	6	24	9	0.06	0.28
November 1960	0.39[2]	0.58	15	8	37	14	0.05	0.37
December 1960	0.81	0.85	21	8	26	9	0.08	0.37
January 1961	0.77	0.76	18	5	24	7	0.06	0.23
Average 1959	-------	-------	-------	-------	46	12	-------	-------
Average 1960	-------	-------	-------	-------	28	12	-------	-------

[1] Data taken from *Quarterly Summary Report*, HASL-113, dated July 1, 1961.

[2] Questionable calcium value.

[3] Values calculated by staff of Data Collation and Analysis Unit, Division of Radiological Health, Public Health Service, from U. S. Department of Agriculture data on average daily per capita consumption of 3.6 gm/day of whole-wheat bread and 46.2 gm/day of white bread (see *Radiological Health Data*, Volume I, Number 5).

SECTION III. — MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960, a processed milk sampling program of 60 stations was established. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Alabama, and the Southwestern Radiological Health Laboratory at Las Vegas, Nevada, provide analytical services for the new program.

The objectives of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program more directly related to the milk consumed by the population was necessary. The Public Health Service, Department of Health, Education, and Welfare, acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of a comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors including laboratory methodology and collection methods. Until this study has been completed, and additional experience has been

gained under the new program, no valid interpretation can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product build-up, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective of the project was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data.*

One-gallon raw milk samples are collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000- and 90,000-gallon lots. The concentration of iodine-131, barium-140, and cesium-137 are currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the buildup of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium and strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of analytical procedures.

Table 1 presents first quarter averages for 1961 and the April 1961 data for the raw milk sampling stations.

Processed Milk Area Sampling Stations

The processed milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases of this expanded sampling and radioassay program are:

1. to measure the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. to provide one sampling point within

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS, FIRST QUARTER AND APRIL 1961

[Radioactivity concentrations in $\mu\mu$c/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137		Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	First quarter	April	First quarter	April	First quarter	April		First quarter	April	First quarter	April	First quarter	April
Atlanta, Ga.	1.18	1.19	13	11	25	25	Salt Lake City, Utah	1.19	1.18	4	3	10	<5
Austin, Tex.	1.16	1.17	7	3	15	10	Spokane, Wash.	1.22	1.14	7	7	15	15
Chicago, Ill.	1.17	1.14	6	9	20	15	St. Louis, Mo.	1.26	1.18	13	20	25	20
Cincinnati, Ohio	1.21	1.17	8	10	15	15							
New York, N.Y.	1.11	1.13	9	7	20	20							
Sacramento, Calif.	1.19	1.16	5	2	10	5	Average	1.19	1.16	8	8	15	14

Note: I^{131}, Sr^{89} and Ba^{140} are below minimum detectable limits for samples collected in April. These limits are 10 $\mu\mu$c/liter for I^{131} and Ba^{140} and 5 $\mu\mu$c/liter for Sr^{89}.

each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

At the present time, radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140} and I^{131} are being performed. The latter three radionuclides are not presently found in milk by the current methods of detection. The lower level of detection for Sr^{89} is 5 μμc/liter, and for Ba^{140} and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for a more complete monitoring of the milk supply.

Table 2 presents first quarter averages for 1961 and the April 1961 data for the processed milk sampling stations.

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, FIRST QUARTER AND APRIL 1961

[Radioactivity concentrations in $\mu\mu$c/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137		Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	First quarter	April	First quarter	April	First quarter	April		First quarter	April	First quarter	April	First quarter	April
Albuquerque, N. Mex.	1.05	1.02	5	3	<5	<5	Memphis, Tenn.	1.30	1.32	8	14	<5	<5
Atlanta, Ga.	1.21	1.24	7	8	5	10	Milwaukee, Wis.	1.23	1.27	5	6	<5	20
Austin, Tex.	1.26	1.23	2	3	<5	<5	Minneapolis, Minn.	1.00	1.01	7	9	<5	5
Baltimore, Md.	1.28	1.24	6	7	5	15	New Orleans, La.	1.31	1.30	8	10	10	25
Boston, Mass.	1.27	1.24	8	9	10	30	New York, N.Y.	[a] 1.18	1.19	[a] 7	8	[a] 5	20
Buffalo, N.Y.	[a] 1.18	1.23	[a] 6	7	[a] <5	5	Norfolk, Va.	[a] 1.20	1.31	[a] 7	8	[a] <5	15
Burlington, Vt.	1.23	1.24	9	7	5	10	Oklahoma City, Okla.	1.29	1.25	5	8	<5	<5
Charleston, S.C.	1.35	1.24	8	12	5	15	Omaha, Nebr.	1.05	1.12	7	3	5	<5
Charleston, W. Va.	1.21	1.24	5	6	<5	<5	Palmer, Alaska	1.08	1.06	6	10	<5	<5
Charlotte, N.C.	1.28	1.28	9	14	<5	<5	Philadelphia, Pa.	1.27	1.24	7	9	<5	15
Chattanooga, Tenn.	1.33	1.36	8	14	<5	10	Phoenix, Ariz.	1.09	.93	2	5	<5	<5
Chicago, Ill.	[a] 1.16	1.18	[a] 6	9	[a] <5	<5	Pittsburgh, Pa.	1.24	1.36	9	12	<5	<5
Cincinnati, Ohio	1.24	1.26	7	8	<5	10	Portland, Me.	[a] 1.20	1.25	[a] 10	12	[a] 10	35
Cleveland, Ohio	1.21	1.20	6	9	<5	<5	Portland, Oreg.	1.11	1.07	8	10	10	20
Dallas, Tex.	1.29	1.22	5	10	<5	10	Providence, R.I.	1.26	1.06	9	7	10	25
Denver, Colo.	1.03	.98	6	5	5	<5	Sacramento, Calif.	1.12	1.06	3	6	<5	<5
Des Moines, Iowa	1.07	1.01	7	8	<5	<5	Salt Lake City, Utah	1.05	1.03	4	4	5	<5
Detroit, Mich.	1.19	1.16	6	7	<5	<5	San Francisco, Calif.	1.05	.95	3	7	<5	5
Grand Rapids, Mich.	1.24	1.25	7	5	<5	<5	San Juan, P.R.	1.15	1.20	3	4	<5	<5
Hartford, Conn.	1.19	1.22	7	9	10	20	Seattle, Wash.	1.09	.94	7	8	10	15
Helena, Mont.	1.04	.98	4	6	5	<5	Spokane, Wash.	1.12	1.06	7	6	5	5
Honolulu, Hawaii	1.05	.92	4	5	<5	5	St. Louis, Mo.	1.01	1.06	7	8	10	15
Idaho Falls, Idaho	1.05	.99	5	4	<5	<5	Syracuse, N.Y.	1.22	1.12	6	7	<5	15
Indianapolis, Ind.	1.26	1.28	7	7	<5	<5	Tampa, Fla.	1.26	1.26	5	8	35	90
Jackson, Miss.	1.37	1.38	10	16	5	15	Trenton, N.J.	1.24	1.21	7	8	<5	5
Kansas City, Mo.	1.05	[b]	7	[b]	<5	[b]	Washington, D.C.	1.23	1.20	6	6	<5	<5
Laramie, Wyo.	1.06	.96	5	5	<5	5	Wichita, Kans.	1.05	1.01	5	6	<5	5
Las Vegas, Nev.	1.03	.96	3	3	<5	<5	Wilmington, Del.	1.22	1.20	7	7	<5	15
Little Rock, Ark.	1.27	1.24	13	20	5	25							
Louisville, Ky.	1.21	1.20	7	10	<5	10							
Manchester, N.H.	1.21	1.20	8	11	15	35	Average	1.18	1.16	6	8	<5	10

[a] Average based on two months.
[b] No sample collected.

SECTION IV. — WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network operates under the provision of Section 4(c) of the Federal Water Pollution Control Act, which states ". . . The Secretary shall . . . . collect and disseminate basic data . . . (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local agencies, and industrial organizations commenced operations in October 1957. At present, there are 86 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of approximately 300 stations will be in operation. Radioactivity is not yet being reported for a few of the more recently established stations.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing, the beta activity in most raw waters is generally approaching a level attributable solely to natural sources. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably in the data for the Columbia, Tennessee and Animas Rivers.

For the first two years of the network operations, beta determinations were made on weekly samples. Alpha determinations were reported generally on composites of more than one weekly sample.

Beginning January 1, 1960 the frequency of beta determinations has varied depending on the status of each particular station. For the first operating year of each new station, analyses have been conducted weekly. Weekly analyses are continued indefinitely from all stations which may be affected by waste discharges from nuclear installations. Semi-

monthly determinations (on composites of 2 or 3 weekly samples) are conducted for stations which still show some beta activity above background. Monthly determinations (on composites of all samples received from a station during the month) are conducted on samples from streams where beta activity is at background levels.

Beginning January 1, 1960, the frequency of alpha determinations has also been changed. For the first operating year of each new station, analyses have been done weekly. Semimonthly determinations are conducted at some collecting points on the Animas and Colorado Rivers by compositing 2 or 3 weekly samples. The remainder of the stations have determinations made quarterly on composites of all samples taken during that quarter.

Schedules of determinations are so arranged that each river basin has one gross alpha determination each month. All data reported in table 1 represent the average of all information available for the month indicated. Reported strontium-90 data are the results of determinations on composite samples for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

National Water Quality Network Annual Compilation of Data, PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

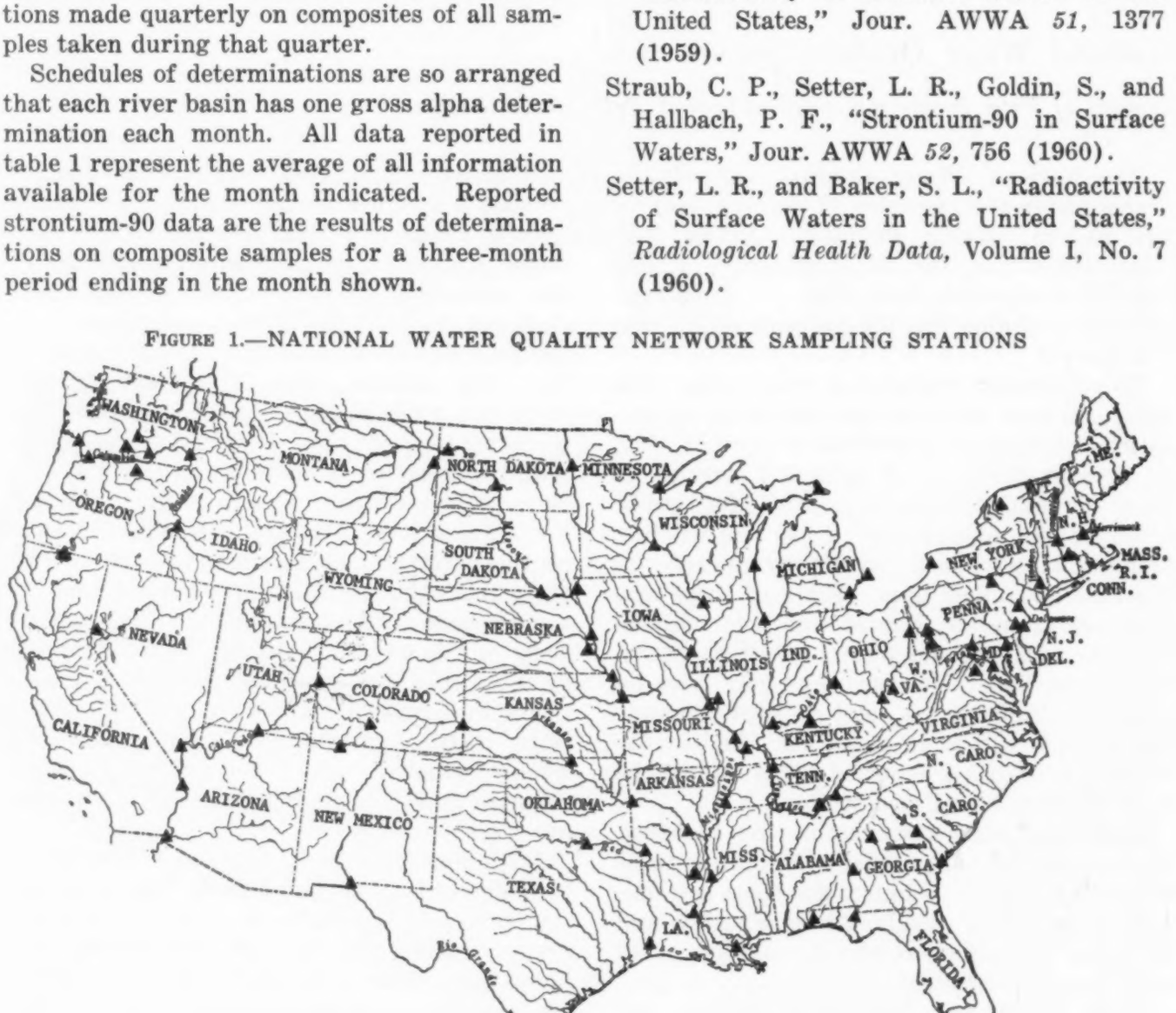
"Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167-169.

Setter, L. R., Regnier, J. E., and Diephaus, A., "Radioactivity of Surface Waters in the United States," Jour. AWWA *51*, 1377 (1959).

Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," Jour. AWWA *52*, 756 (1960).

Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, Volume I, No. 7 (1960).

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS



As of June 1, 1961

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Concentrations in μμc/liter]

Station	Quarter ending December 31, 1960	March 1961					
	Strontium-90	Beta activity			Alpha activity		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	[a]	2	<1	2	<1	0	<1
Animas River: Cedar Hill, N. Mex.		598	19	617	64	16	80
Apalachicola River: Chattahoochie, Fla.		0	<1	<1	1	0	1
Arkansas River:							
Coolidge, Kans.		0	0	0	0	49	49
Ponca City, Okla.		38	0	38	1	5	6
Pendleton Ferry, Ark.	[b]	0	0	1	1	0	1
Chattahoochie River:							
Atlanta, Ga.	0.3	0	0	0	1	0	1
Columbus, Ga.		0	1	1	1	0	1
Colorado River:							
Loma, Colo.		2	0	2	10	14	24
Page, Ariz.	0.4	28	3	31	25	14	39
Hoover Dam, Ariz.-Nev.		0	12	12	0	6	6
Parker Dam, Ariz.-Calif.	1.2	0	20	20	0	5	5
Yuma, Ariz.		0	22	22	1	13	14
Columbia River:							
Wenatchee, Wash.		<1	<1	2	<1	0	<1
Pasco, Wash.		103	526	629	0	0	0
Bonneville Dam, Oreg.	0.5	66	176	242			
Clatskanie, Oreg.		19	43	62			
Delaware River:							
Martins Creek, Pa.		0	2	2	0	0	0
Philadelphia, Pa.		0	0	0	0	1	1
Escambia River: Century, Fla.	[b]	0	0	0	1	0	1
Great Lakes:							
Buffalo, N.Y.		0	0	0	0	0	0
Port Huron, Mich.		0	0	0	0	0	0
Gary, Ind.		0	0	0	0	0	0
Duluth, Minn.		0	0	0	0	0	0
Milwaukee, Wisc.	0.2	0	0	0	<1	<1	<1
Sault Ste. Marie, Mich.		0	0	0	0	0	0
Hudson River: Poughkeepsie, N.Y.	0.4	2	0	2	2	0	2
Illinois River: Peoria, Illinois	0.5	1	6	7	2	1	3
Kanawha River: Winfield Dam, W. Va.		<1	0	<1	0	0	0
Klamath River: Copco, Oreg.		0	2	2	0	<1	<1
Little Miami River: Cincinnati, Ohio		1	0	1	2	0	2
Mississippi River:							
Minneapolis, Minn.		0	0	0	0	1	1
Burlington, Iowa		0	6	6	5	1	6
E. St. Louis, Ill.		87	6	93	28	0	28
Cape Girardeau, Mo.		76	0	76	30	0	30
West Memphis, Ark.	1.0	10	3	13	7	0	7
Delta, La.		9	5	14	4	1	5
New Orleans, La.		5	1	6	2	0	2
Missouri River:							
Williston, N.D.		1	0	1	2	3	5
Bismarck, N.D.		0	3	3	0	3	3
Yankton, S.D.		0	1	1	0	4	4
Omaha, Nebr.		122	3	125	61	2	63
St. Joseph, Mo.	0.5	149	0	149	96	2	98
Kansas City, Kans.		481	0	481	86	1	87
St. Louis, Mo.		4	10	14	18	2	20
Ohio River:							
East Liverpool, O.		0	2	2	1	0	1
Huntington, W. Va.		1	0	1	3	0	3
Wheeling, W. Va.	0.6						
Cincinnati, Ohio		4	1	5	2	<1	2
Evansville, Ind.	0.8	0	0	0	0	0	0
Cairo, Ill.		12	2	14	2	0	2
Potomac River:							
Hagerstown, Md.		4	0	4	1	0	1
Great Falls, Md.		4	4	8	1	0	1
Red River, North: Grand Forks, N.D.		0	5	5	0	2	2
Red River, South:							
Index, Ark.		3	0	3	2	1	3
Alexandria, La.		11	2	13	5	0	5
Denison, Tex.	0.7	0	0	0	0	0	0
Rio Grande River:							
Alamosa, Colo.		0	0	0	0	2	2
El Paso, Tex.		0	0	0	8	5	13
Laredo, Tex.		0	0	0	0	2	2
Brownsville, Tex.		<1	0	<1	0	2	2
Sabine River: Ruliff, Tex.		<1	2	2	<1	0	<1
St. Lawrence River: Massena, N.Y.	0.6	<1	<1	<1	0	0	0
Schuylkill River: Philadelphia, Pa.	[b]	0	2	2	0	0	0
Savannah River:							
Port Wentworth, Ga.	0.5	<1	26	26	1	0	1
North Augusta, S.C.		0	0	0	0	0	0
Snake River: Wawawai, Wash.		0	0	0	0	1	1
Susquehanna River:							
Sayre, Pa.		0	2	2	<1	<1	1
Conowingo, Md.	0.4	0	0	0	2	0	2
Tennessee River:							
Chattanooga, Tenn.	0.9	0	52	52			
Bridgeport, Ala.		<1	87	87	1	0	1
Yellowstone River: Sidney, Mont.		15	0	15	8	7	15

[a] Dash denotes no sample received or no determinations made.
[b] Insufficient sample for analysis.

Strontium-90 In Tap Water

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Atomic Energy Commission's Health and Safety Laboratory performs analyses for strontium-90 concentrations in tap water for Richmond, California, and New York City on a monthly basis. Previous data were presented in *Radiological Health Data*, Volume I, Numbers 1, 5, and 9, and Volume II, Number 4.

TABLE 1.—STRONTIUM-90 IN TAP WATER[1] FOURTH QUARTER 1960

Location	Month	Activity ($\mu\mu$c/liter)
Richmond, California (40 liters per sample)	October	0.26
	November	0.28
	December	0.26
	Average 1959	0.29
	Average 1960	0.26
New York City (100-200 liters per sample)	October	0.33
	November	0.34
	December	0.34
	Average 1959	0.40
	Average 1960	0.47

[1] Data from *Quarterly Summary Report*, HASL-113, dated July 1, 1961.

Study Of Radium-226 Content Of Midwest Water Supplies [1]

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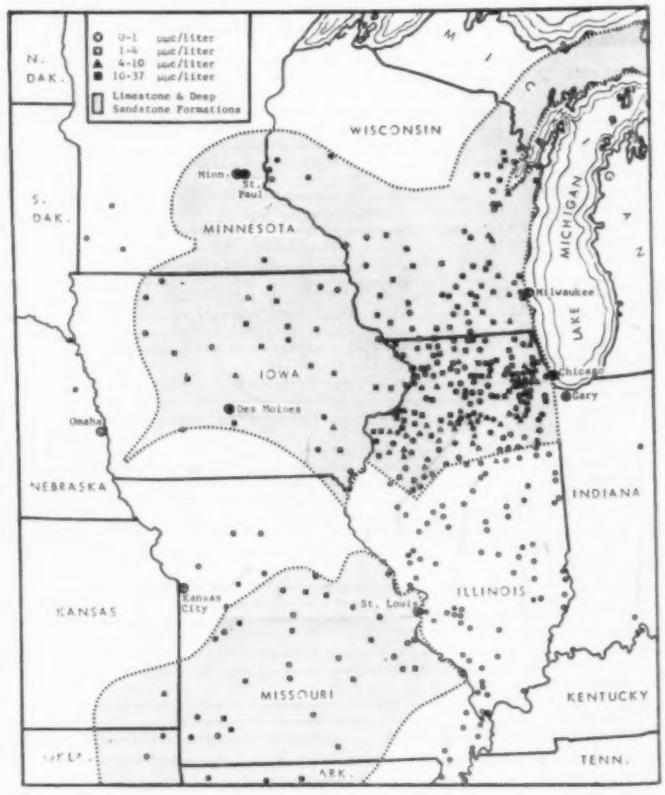
In previous work, water from certain midwest municipal water systems was found to contain less than 0.03 to 37 micromicrograms per liter ($\mu\mu$g liter) of radium-226 (Ra^{226}), concentrations which correlate well with source type and method of softening. Water derived from surface sources such as rivers or lakes, wells penetrating unconsolidated sand or gravel deposits of glacial origin, limestone formations of Silurian or Devonian age were, with rare exception, found to contain less than 1 $\mu\mu$g Ra^{226}/liter. In contrast, wells penetrating deep sandstone formations of Ordovician, Cambrian or Pre-Cambrian ages had Ra^{226} contents from 1 to 37 $\mu\mu$g/liter (1, 2).

These deep sandstone formations are known to exist over an area not less than 300,000 square miles in extent (3). In a portion of this area the quality and quantity of the water is suitable for drinking and other municipal purposes. The broken line in figure 1 outlines the two largest areas in the United States obtaining water from consolidated rock (limestone and deep sandstone) formations (4).

FIGURE 1.—RADIUM-226 CONTENT OF MUNICIPAL DRINKING WATER



[1] Reported in *Semiannual Report*, January through June 1960, Radiological Physics Division, Argonne, National Laboratory.

This area is seen to cover much of Wisconsin, Minnesota, Iowa, Illinois, and Missouri.

As part of an extensive study of the Ra^{226} content of municipal drinking waters in these and adjoining regions, the study of Illinois is complete, with at least one water sample collected and analyzed from 163 of the 165 communities comprising more than 99 percent of the total population suspected of consuming water with high radium content.

The distribution of the samples and the range of Ra^{226} content is shown in figure 1. On this map, the symbols denote the ranges of Ra^{226} content in the drinking water of 0-1, 1-4, 4-10, and 10-37 μμg/liter.

With two exceptions, concentrations of Ra^{226} in excess of 4 μμg/liter have been found thus far only in Illinois, Iowa, and Wisconsin. Cities having Ra^{226} content greater than 10 μμg/liter in their water supply have been found, thus far, only in Illinois, Iowa, and Missouri, and their total population is about 37,000 (1950 census). The total population, identified to date consuming water in excess of 1 μμg/liter is 1,000,000. Of these, about one-half or 480,000 consume water having a Ra^{226} content in excess of 4 μμg/liter, a level leading to a whole-body radium content presently estimated to be at least 5 times that obtainable from normal food alone. The data are summarized in table 1.

TABLE 1.—SUMMARY OF POPULATIONS CONSUMING WATER IN VARIOUS RANGES OF Ra^{226} CONTENT

	Range (μμg/liter)	Number of cities	Total population (1950 census)
Illinois	0.0-0.9	131	1,035,414
	1.0-3.9	56	248,248
	4.0-9.9	41	320,506
	10-37	19	30,261
Iowa	0.0-0.9	16	156,914
	1.0-3.9	10	43,855
	4.0-9.9	4	38,716
	10-11.7	1	5,843
Missouri	0.0-0.9	32	155,830
	1.0-3.9	14	81,314
	4.0-9.9	0	0
	10-10.4	1	1,218
Wisconsin	0.0-0.9	28	196,722
	1.0-3.9	25	221,175
	4.0-9.9	8	81,740
	≥10	0	0
Total	0.0-0.9	207	1,544,880
	1.0-3.9	105	595,108
	4.0-9.9	53	440,964
	≥10	21	37,322
Grand total		386	2,617,418

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(1) Lucas, H. F., Jr., and F. H. Ilcewicz. J. Am. Water Works Assoc. *50* 1523-1532 (1958).
(2) Lucas, H. F., Jr. Radiological Physics Division Semiannual Report, ANL-5919 (September 1958) pp. 58-60.
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Radium-228 In Midwest Well Waters [1]

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Argonne National Laboratory, U.S. Atomic Energy Commission

Concurrent with the program to determine the radium-226 (Ra^{226}) concentration levels in well waters from the midwestern states of Illinois, Wisconsin, Missouri, and Iowa, measurements of the radium-228 (Ra^{228}), (Mesothorium I) levels are also being made (1-4). Waters were selected having Ra^{226} levels equal to or greater than 4μμc/liter, and these, without exception were obtained from wells penetrating deep sandstone formations. Although no definite pattern can be established, it appears that in Illinois certain areas yield reasonably constant ratios of Ra^{228}/Ra^{226}, but that throughout the state this ratio varies from 0.04 to 2.4 and is dependent upon the aquifer or aquifers from which the water is drawn (5). Previous work on samples from other than deep sandstone wells has shown that the Ra^{226} and Ra^{228} concentrations are low or nearly equal, i.e., the Ra^{228}/Ra^{226} ratio approaches unity (3).

[1] Reported in *Semiannual Report*, January through June, 1960, Radiological Physics Division, Argonne National Laboratory.

The data for some Illinois deep sandstone wells are presented in table 1 and are tabulated by ascending values of the Ra^{228}/Ra^{226} ratio. The table also classifies the wells as to the type of aquifer from which the principal supply is believed to be drawn. The information regarding the wells was taken primarily from Bulletin No. 40 of the Illinois State Water Survey and from the sampling record sheet completed by the local water department (6).

It is evident from table 1 that waters derived chiefly from St. Peters sandstone (Ordovician system) are generally low in Ra^{228} but high in Ra^{226}, whereas waters derived from the underlying Galesville sandstone formation (Cambrian system) have more nearly equal concentrations of the two isotopes. In each case, however, there are exceptions to these general statements, and for these no good explanation is available other than lack of information describing the well or local geological conditions.

To illustrate the latter point, the towns of Lostant, Toluca, Wenona, and Minonk may be cited. These four towns are located in an area which has a north-south dimension of about 15 miles and an east-west dimension of about 6 miles in a region where a geological fault is known to exist (7). The information available indicates that the wells in these towns penetrate the St. Peters sandstone, but the average Ra^{228}/Ra^{226} ratio is 0.81 for the group in contrast with an average of 0.11 for the first 15 towns listed in table 1.

TABLE 1.—RADIUM CONTENT OF WATER FROM SOME DEEP SANDSTONE WELLS IN ILLINOIS

Town	St. Peter's Sandstone	Galesville Sandstone	Mt. Simon Sandstone	Limestone	Other	Radium-228 ($\mu\mu$c/liter)[a]	Radium-226 ($\mu\mu$c/liter)[b]	Ratio:— Ra^{228}/Ra^{226}
Tonlon	[c]×					1.3	36.0	0.04
Ipava	×					1.9	25.0	0.07
Farmington	×					0.6	7.5	0.08
Depue #1	×					0.7	9.2	0.08
Viola	×					0.6	8.1	0.08
Glasford	×			×		1.1	11.6	0.09
Depue #2-T	×					1.0	9.7	0.10
Depue #2	×					1.1	9.6	0.11
Alpha	×			×		0.7	6.4	0.11
Woodhull	×			×		0.5	4.2	0.12
Shannon	×					2.1	17.0	0.12
Odell	×					1.5	11.2	0.13
Biggsville	×			×		2.4	16.0	0.15
Bushnell	×					3.4	18.0	0.19
Elmwood	×					1.8	8.2	0.22
Sterling	×	×				0.9	3.9	0.23
Galesburg	×	×				2.0	8.1	0.25
Monmouth	×	×				2.0	6.6	0.30
Chenoa	×			×	(d)	2.2	7.3	0.30
Fulton		×	×			1.5	4.8	0.31
Silvis				×	(d)	1.5	4.6	0.33
Ladd	×				×	2.6	7.4	0.35
Standard	×					2.4	6.6	0.36
Byron	×	×	×			1.8	4.7	0.38
Freeport	×				×	1.4	3.5	0.40
Lake Bluff	× (?)	×	×	×		2.2	5.8	0.42
Lombard	×	×				3.6	8.6	0.42
Wilmington	×	×		×		5.3	10.2	0.52
Elmhurst	×	×				2.7	5.1	0.53
Ottawa		×				3.8	6.4	0.59
De Kalb #6	×	×				2.9	4.9	0.59
Kewanee	×	×				4.9	8.1	0.60
Rockford		×	×		×	2.2	3.5	0.63
De Kalb #7	×	×				2.0	3.1	0.64
Lostant	×					6.5	9.9	0.66
Savanna			×			2.0	3.0	0.67
Plainfield	×	×				5.4	8.0	0.68
Lockport	×	×				7.9	11.2	0.70
Toluca	×					5.3	7.3	0.73
Villa Park	×	×	×	×		3.3	4.2	0.78
Morris #4		×				6.6	8.0	0.82
Oregon		×	×			2.7	3.1	0.87
Geneva		×	×			5.8	6.4	0.91
Braidwood	×	×		×		5.8	6.4	0.91
Minonk #2	×			×		7.1	7.8	0.91
Wenona	×					9.1	9.3	0.98
Argonne deep well	×	×	×	×		5.2	5.0	1.04
Joliet		×				7.0	6.7	1.04
Aurora	× (?)	×	×			8.0	6.8	1.18
Kinsman	×			×	×	5.4	4.4	1.23
Batavia		×	×			8.0	5.6	1.43
Morris	×					5.6	2.3	2.43

[a] Estimated error in Ra^{228} values is ±10%.
[b] Statistical counting error equal to or less than 3%.
[c] "×" denotes formation from which sample was drawn.
[d] New Richmond sandstone.

TABLE 2.—RADIUM CONTENT OF WATER FROM SOME DEEP SANDSTONE WELLS IN WISCONSIN AND MISSOURI

Town	Radium-228[a] ($\mu\mu$c/liter)	Radium-226[b] ($\mu\mu$c/liter)	Ratio Ra^{228}/Ra^{226}
Wisconsin			
Hartford	1.5	6.2	0.24
Fond du Lac	2.7	6.6	0.41
Burlington	2.0	4.2	0.47
Peshtigo	2.1	3.6	0.58
Kaukauna	2.7	4.0	0.67
Oconto	2.4	3.6	0.67
Menomenee Falls	5.0	4.7	1.06
Waukesha	8.8	4.2	2.09
Missouri			
Clinton #2	1.8	10.4	0.17
Clinton #1	1.9	9.0	0.21
Concordia	4.4	10.5	0.42

[a] Estimated error ±10%.
[b] Statistical counting error equal to or less than 3%.

Some deep sandstone wells in Wisconsin and Missouri have also been analyzed for both Ra^{228} and Ra^{226}. Table 2 is a summary of the data obtained thus far.

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(4) Lucas, H. F., Radiological Physics Division *Semi-annual Report*, ANL 6199 (August 1960), p. 82.
(5) Lucas, H. F., and Krause, D. P. Radiology *74* 114 (1960).
(6) Hanson, Ross, *Public Ground-Water Supplies in Illinois*, Illinois State Water Survey Bulletin No. 40 (1950).
(7) Bretz, J. Harlan, *Geology of the Chicago Region*, Illinois State Geological Survey (Part I), Bulletin No. 65.

SECTION V. — OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise, but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, APRIL 1961

Station location	Average (mr/hr)	Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Indianapolis, Ind	0.01	Oklahoma City, Okla	0.03
Fairbanks, Alaska	[a]	Iowa City, Iowa	0.02	Ponca City, Okla	0.04
Juneau, Alaska	0.01	Topeka, Kans	0.02	Portland, Oreg	0.02
Phoenix, Ariz	0.01	New Orleans, La	0.01	Harrisburg, Pa	0.01
Little Rock, Ark	0.02	Baltimore, Md	0.02	Providence, R.I	0.02
Berkeley, Calif	0.01	Lawrence, Mass	0.02	Columbia, S.C	0.02
Los Angeles, Calif	[a]	Lansing, Mich	0.02	Pierre, S. Dak	0.02
Denver, Colo	0.02	Minneapolis, Minn	0.01	Austin, Tex	0.01
Hartford, Conn	0.01	Pascagoula, Miss	[a]	El Paso, Tex	0.02
District of Columbia	0.02	Jefferson City, Mo	0.01	Salt Lake City, Utah	0.02
Jacksonville, Fla	0.01	Helena, Mont	0.07	Richmond, Va	0.01
Atlanta, Ga	[a]	Trenton, N.J	0.02	Seattle, Wash	0.02
Honolulu, Hawaii	0.03	Santa Fe, N. Mex	[a]	Cheyenne, Wyo	0.02
Boise, Idaho	0.01	Albany, N.Y	0.02	Madison, Wis	0.01
Springfield, Ill	0.01	Gastonia, N.C	0.02		

[a] No data received.

Survey Of Radioactivity In Animal Fodder

Food and Drug Administration

A part of the continuing surveillance of radioactivity in foods by the Food and Drug Administration is concerned with the levels of strontium-90 in animal fodders. *Radiological Health Data*, Volume I, Number 9 presented the strontium-90 analysis of animal fodder collected in 1959. The following table gives the results of analysis of feeds collected in 1960 by representatives of Food and Drug Administration Districts.

TABLE 1.—STRONTIUM-90 CONTENT OF ANIMAL FODDERS, 1960

[Concentrations in $\mu\mu c$/kg original material]

Product	Harvest date	Area		Strontium-90
		County	State	
Alfalfa hay	August	Hamilton	Ohio	157
Timothy & clover hay	August	Hamilton	Ohio	426
Lespedeza hay	August 15	Forsyth	North Carolina	248
Alfalfa hay	August 15	Forsyth	North Carolina	297
Alfalfa hay	March 30, May 20	Sumter	Georgia	425
Lespedeza hay	September 15	Henry	Georgia	446
Peanut hay	August	Irwin	Georgia	578
Peanut hay	August 21	Tift	Georgia	708
Peanut hay	August 28	Ben Hill	Georgia	721
Peanut hay	September 5	Worth	Georgia	931
Alfalfa hay	August 18	Conejos	Colorado	64
Dry sugar beet pulp	October	Buffalo & Kearney	Nebraska	127

Global Integrals Of Strontium-90 Fallout [1]

Kosta Telegadas
U.S. Weather Bureau

Monthly collections of fallout have been made for a period of several years using both steel pots and ion-exchange collectors (1). The samples are analyzed for strontium-90 (Sr^{90}) and several other radioisotopes.

The geographical distribution of fallout supports the north-south distribution noted by previous articles on soil (2) and limited pot data (2). The difference between Northern and Southern Hemisphere shows the same seasonal trend also suggested in earlier data, i.e., a maximum excess of Sr^{90} in the Northern over the Southern Hemisphere during the spring of the Northern Hemisphere, and a minimum difference during the spring of the Southern Hemisphere. The seasonal trend of absolute values in the North Temperate Zone is especially marked.

The high geographic variability of fallout sampling and analyses requires "smoothing" by grouping of the data. Several methods can be used to smooth, or average, the data in order to compute the total global ground fallout. These methods can be compared to see if they are consistent as well as to determine the variability between the two methods.

The first method consists of determining the arithmetic average of Sr^{90} deposition for each 10 degree latitude band and drawing a smooth curve through these average latitudinal values. This method assumes that the arithmetic average of selected stations is representative of the average value for the whole latitude belt. Since there are only a limited number of stations, this average may bias the answer toward

[1] From *Quarterly Summary Reports*, HASL-84, April 1, 1960; HASL-95, October 1, 1960; and HASL-111, April 1, 1961.

FIGURE 1.—SEASONAL LATITUDINAL CURVES OF STRONTIUM-90 DEPOSITION (JUNE 1958-FEBRUARY 1960)

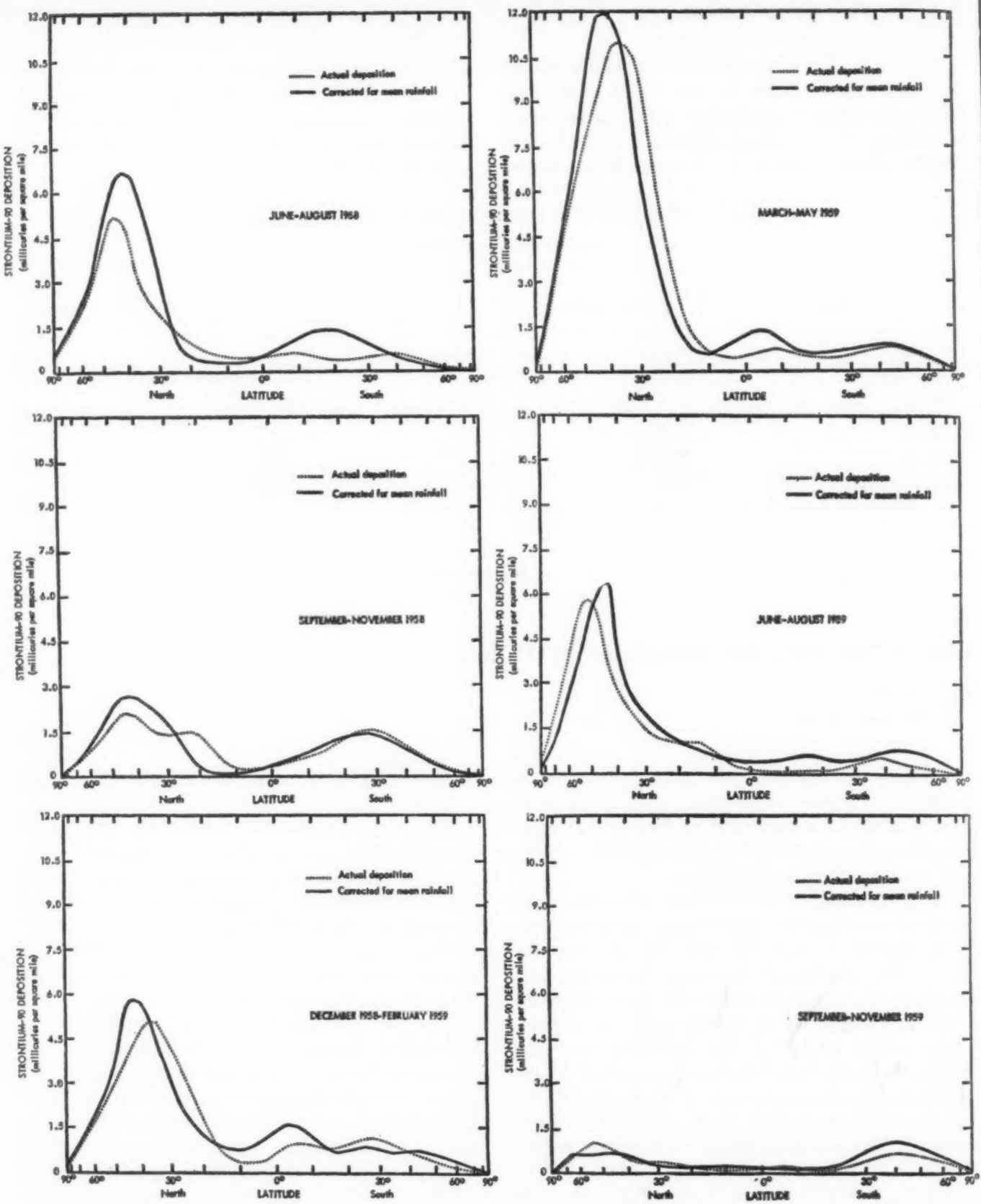


FIGURE 1.—SEASONAL LATITUDINAL CURVES OF STRONTIUM-90 DEPOSITION Con.

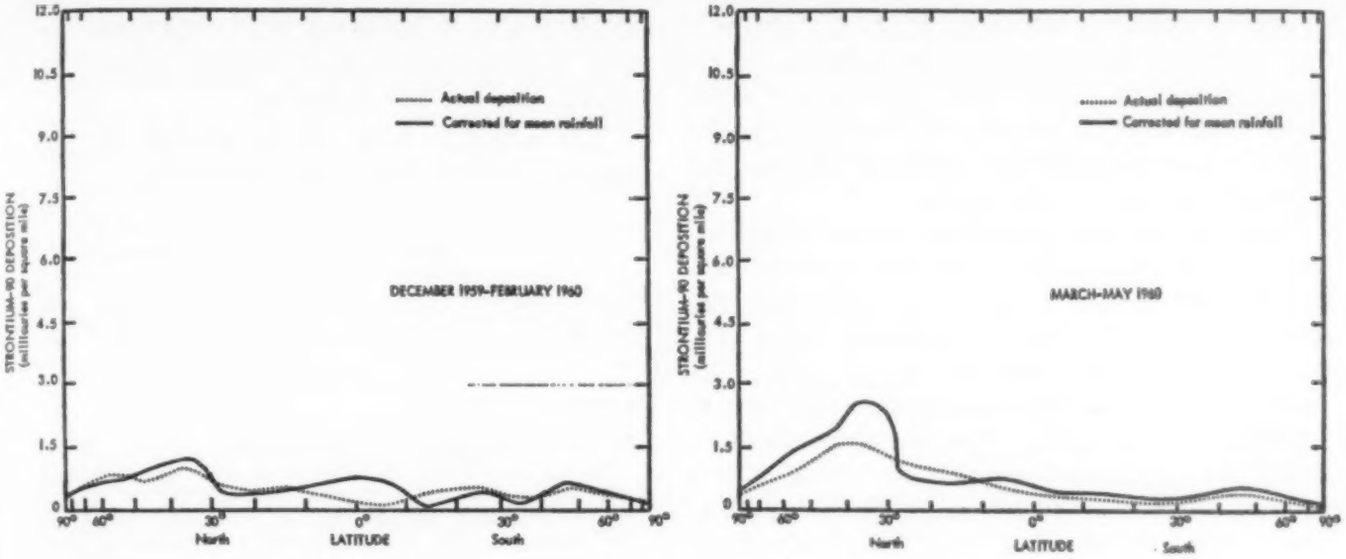


TABLE 1.—TOTAL WORLD GROUND DEPOSITION OF STRONTIUM-90, JUNE 1958–MAY 1960

[Deposition in megacuries]

Period	Method	Latitudes				Total	Average total	Difference[1] (percent)
		North			South			
		30°–90°	0°–90°	0°–90°	0°–90°			
June–Aug. 1958	Actual	0.13	0.05	0.18	0.04	0.22	0.26	27
	Rainfall correction	0.19	0.03	0.22	0.07	0.29		
Sep.–Nov. 1958	Actual	0.06	0.04	0.10	0.07	0.17	0.19	16
	Rainfall correction	0.09	0.02	0.11	0.09	0.20		
Dec. 1958–Feb. 1959	Actual	0.15	0.06	0.21	0.07	0.28	0.29	4
	Rainfall correction	0.16	0.06	0.22	0.07	0.29		
Mar.–May 1959	Actual	0.34	0.12	0.46	0.05	0.51	0.52	2
	Rainfall correction	0.37	0.08	0.45	0.07	0.52		
June–Aug. 1959	Actual	0.16	0.04	0.20	0.03	0.23	0.25	12
	Rainfall correction	0.16	0.04	0.20	0.06	0.26		
Sep.–Nov. 1959	Actual	0.06	0.03	0.09	0.03	0.12	0.12	0
	Rainfall correction	0.04	0.03	0.07	0.05	0.12		
Dec. 1959–Feb. 1960	Actual	0.037	0.026	0.063	0.041	0.104	0.110	10
	Rainfall correction	0.042	0.026	0.068	0.047	0.115		
Mar.–May 1960	Actual	0.056	0.042	0.098	0.029	0.127	0.143	22
	Rainfall correction	0.083	0.036	0.119	0.040	0.159		

[1] Difference (%) $= \left[\frac{2(\text{Method 1} - \text{Method 2})}{\text{Method 1} + \text{Method 2}}\right] 100.$

higher values if most of the fallout stations are in rainy areas or toward a low answer if more are in a dry region.

The second method is an attempt to compensate for the climatic difference at sampling stations compared with the average rainfall in a latitude band. The specific activity (mc/mi²/inch of rain) is determined for each station by months. The arithmetic average is then computed for the various latitude belts. To determine the total fallout, the average specific activity in each latitude band is multiplied by the precipitation in the same 10° latitude band. The precipitation in these bands are given by

Möller (3) for each of the four seasons. This method assumes that the average precipitation given by Möller is the same that has occurred for the time period under consideration. This treatment of the data may be in error since there is an inverse correlation between specific activity and precipitation amounts whereas the method assumes no correlation.

Smooth seasonal latitudinal curves of deposition for the two methods for the various time periods are shown in figure 1. Although the difference between the two methods for a particular 10° latitude belt can be as much as a factor of two, the significant features are approximately the same. The curves in this figure were integrated to give the total world ground fallout for the periods under consideration. The total world ground fallout for both methods, expressed in megacuries of Sr^{90}, are shown in table 1. Although there can be as much as a factor of two in the difference between the two methods for a given latitude belt, the difference between methods ranges from 2 to 27 percent for the world total. Probably the best world-wide fallout amount is an average of the two methods.

The average total world ground fallout in megacuries for these time periods is:

Period	Deposition	Total
June 1958–May 1959	1.26	1.26
June 1959–Nov. 1959	0.37	1.63
Dec. 1959–May 1960	0.25	1.88

REFERENCES

(1) Environmental Contamination from Weapons Tests, HASL-42, U.S. Atomic Energy Commission, October 1958 and subsequent *Quarterly Summary Reports*, HASL-51, 55, 65, 77, 84, 88, 105, 111 and 113.

(2) Strontium-90 on the Earth's Surface, TID-6567, February 1961, Office of Technical Information, U.S. Atomic Energy Commission.

(3) Möller, F., "Vierteljaharakarten des niederschlags fur die ganze erde", Peterm. Geogr. Mitt., 1, 1-7, 1951.

Registration Of Radiation Sources In California

Department of Public Health, State of California

The registration of radioactive materials, X-ray machines, and other radiation-producing equipment is mandatory under a law enacted by the State of California in 1959. This law, implemented by State Board of Public Health regulations adopted last year, provides for the collection of information relating to the number, location, and use of radiation sources in the State.

The first completed registration forms were

TABLE 1.—REGISTERED RADIATION INSTALLATIONS AS OF MARCH 15, 1961

Nature of installation	Number of installations [1]				Number of individual X-ray units reported
	Total	Percent of total	With radiation machines	With radioactive materials	
Private practices of:					
Dentists	5,737	43.8	5,737		6,974
Physicians	3,558	27.1	3,490	206	4,220
Chiropractors	916	7.0	916	1	945
Osteopaths	586	4.5	583	16	615
Podiatrists	328	2.5	328		331
Hospitals	485	3.7	474	129	2,089
Veterinarians or veterinarian hospitals	465	3.5	464	5	484
Miscellaneous medical services (including clinics, laboratories, health agencies, etc.)	389	3.0	371	33	579
Manufacturing industries	294	2.2	180	179	407
Miscellaneous service industries	109	0.8	66	71	279
Schools or colleges	86	0.7	67	51	292
Government installations, not shown elsewhere	87	0.7	52	41	141
Other	62	0.5	31	36	45
Total	13,102	100.0	12,759	768	17,401

[1] The number of installations with radiation machines and the number with radioactive materials do not add to the total number of installations because 425 installations possess both radiation machines and radioactive materials.

filed in June 1960, shortly after the registration regulations became effective. By March 15, 1961, when 13,102 registrations had been filed and processed, it was possible to commence the task of tabulating the data for analysis and study. The response to the registration requirement has been very good. Many local health agencies have been participating actively in the registration program.

The first summaries of registration data, as of March 15, 1961, are now available. Tables 1 and 2 present information on the number and types of radiation installations registered. As used in these tables, an installation is defined as a location (professional office, building, plant, etc.) where one or more sources of radiation are used, operated, or stored. A separate registration is filed for each installation.

TABLE 2.—REGISTERED RADIATION INSTALLATIONS OF PHYSICIANS IN PRIVATE PRACTICE, BY SPECIALTY, AS OF MARCH 15, 1961[1]

Medical specialty	Number of installations[2]			Number o individual X-ray units reported
	Total	With radiation machines	With radioactive materials	
General medical practice	738	738	2	772
Internal medicine	425	414	16	432
Radiology, roentgenology and nuclear medicine	265	257	67	652
Dermatology	221	218	42	324
Orthopedics	193	193		204
Urology	130	130		139
Ear, nose, throat	43	28	21	28
Pediatrics	41	41		41
Surgery	27	27		28
Cardiology	25	25	1	26
Group practice (including various specialties)	156	156	9	217
Other specialty	88	76	16	89
No specialty stated	1,206	1,187	32	1,268
Total	3,558	3,490	206	4,220

[1] Not included are installations such as hospitals, clinics and health agencies n which radiation sources may be under the control of or used by physicians.
[2] The number of installations with radiation machines and the number with radioactive materials do not add to the total number of installations because 138 installations possess both radiation machines and radioactive materials.

Cesium–137—Potassium Levels In Eight Control Subjects [1]

C. E. Miller and J. B. Corcoran, Radiological Physics Division
Argonne National Laboratory, U.S. Atomic Energy Commission

The total-body gamma-ray spectra of 12 unexposed employees of the laboratory were measured with Human Spectrometer No. 1 on two dates during 1960. These subjects have been measured periodically, usually every three months, since March of 1955.

Their cesium-137 (Cs^{137}) body contents, expressed in units of $\mu\mu c$ Cs^{137} per gram of natural body potassium, have been determined, and the levels in eight subjects are given for eight dates during the past 30 months in table 1. It will be noted that the average Cs^{137} content dropped from 55 $\mu\mu c$ Cs^{137}/gmK during December of 1959, to 49.6 $\mu\mu c$ Cs^{137}/gmK during May of 1960, and to 37.4 $\mu\mu c$ Cs^{137}/gmK during December of 1960. This represents a 10 percent decrease in Cs^{137} content during the first five months of 1960 and 25 percent decrease during the last six months. The same percentage decreases were noted for the other four subjects for these last three dates, but their data were not included in the table since they had not been measured every time on the earlier dates.

A group of 11 male Chicago residents, age 40 to 70 years, measured during the last three months of 1960 contained an average of 38.8 $\mu\mu c$ Cs^{137}/gmK. This value agrees with the amount found for the controls during December of 1960. The spread in individual values was somewhat greater in that they ranged from 20 $\mu\mu c$ Cs^{137}/gmK to 60 $\mu\mu c$ Cs^{137}/gmK while the values of the younger controls ranged from 27.9 to 55.9—a 2 to 1 spread.

[1] Reported in *Semiannual Report*, ANL-6297, July-December 1960, Argonne National Laboratory, Radiological Physics Division.

TABLE 1.—CESIUM-137–POTASSIUM RATIOS IN EIGHT CONTROL SUBJECTS OVER A SPAN OF 30 MONTHS

[Average concentrations in $\mu\mu c$/gm K]

Subject	July 31, 1958	November 20, 1958	March 19, 1959	June 17, 1959	September 14, 1959	December 8, 1959	May 24, 1960	December 15, 1960
1	57	48.5	59	68.5	60	56.2	54	38.4
2	51.5	52	59	54.6	54.5	47.4	49	41.6
3	71.0	68.5	75.2	83.2	68.2	69.5	64.9	55.9
4	43	58	76	81	64.2	62	50.5	33.9
5	47	47.8	54.5	57.2	45.5	42.2	45.4	29.8
6	43.5	46.2	53.5	59	54.7	53.5	48.2	31.6
7	39	39.5	47	46	45.6	45.2	38.2	27.9
8	48.4	51	61.8	65.5	64	63.1	46.6	37.3
Average	50.0	51.4	60.7	64.4	57.1	55.0	49.6	37.4

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The United States Atomic Energy Commission is providing data on environmental levels of radioactivity in the vicinity of major Commission installations to the Public Health Service on a quarterly basis. The data are from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Radiological Health Data, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 8 contain summaries for 17 installations. Summaries follow for the Knolls Atomic Power Laboratory and the S1C Prototype Reactor Facility for the third and fourth quarters of 1960.

Knolls Atomic Power Laboratory

General Electric Company, Schenectady, New York —Issued June 1961

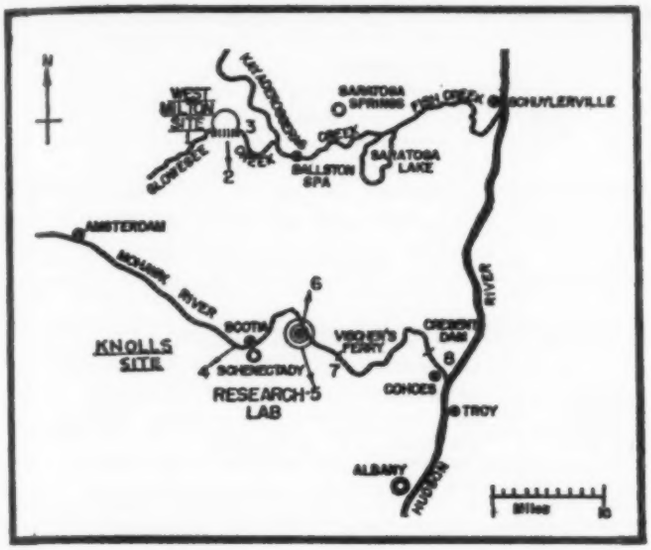
Environmental levels of radioactivity at the Knolls Atomic Power Laboratory (KAPL) have been reported in *Radiological Health Data,* Volume I, Number 9, and Volume II, Number 1. The following report presents the data for the third and fourth quarters 1960, as well as the annual 1960 summary.

The principal responsibility of KAPL is to support the Naval Reactors Program for the Atomic Energy Commission in the development of nuclear power reactors for naval propulsion. The General Electric Company has been the operator of KAPL for the Atomic Energy Commission since 1946.

The Knolls Atomic Power Laboratory consists of two sites: the Knolls Site and the West Milton Site (see figure 1 for geographical locations). The former is located five miles east of Schenectady, New York, on the south bank of the Mohawk River. The West Milton Site is located approximately 18 miles north of Schenectady, in Saratoga County.

Small amounts of radioactive materials are released to the atmosphere and to two surface streams in the area—the Mohawk River at the Knolls Site and the Glowegee Creek at the West Milton Site. Prior to the release of this low level radioactivity to the environment, all KAPL liquid waste and exhaust air systems are carefully and continuously monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted both on- and off-site. Environmental monitoring locations are also given in figure 1. A brief

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, KAPL



1. Glowegee Creek sampling station 150 feet upstream from the entrance of the West Milton Site effluent. Samples of Glowegee Creek water are collected weekly during the warmer seasons.
2. West Milton Site—Environmental radiation levels and particulate airborne radiation levels are sampled continuously at five geographically placed locations on the Site. Precipitation is sampled continuously.
3. Glowegee Creek sampling station 2,640 feet downstream from the West Milton Site. Samples of Glowegee Creek water are collected weekly.
4. General Electric Powerhouse, about eight miles upstream from the Knolls Site; Mohawk River water is sampled continuously.
5. General Electric Laboratory, 4,000 feet west of the Knolls Site, has a continuously operating radiation-level detector and air monitor for particulate airborne materials.
6. Knolls Site environmental particulate air and radiation levels are sampled continuously at three stations at different geographic locations. In addition, precipitation, continuous and proportional samples of combined sewer effluent are collected. Samples of soil and vegetation are collected periodically.
7. Mohawk River water is sampled continuously at the Vischer Ferry Powerhouse which is approximately two miles downstream from the Knolls Site.
8. Cohoes is approximately thirteen miles downstream from the Knolls Site. Samples of untreated Mohawk River water and the Cohoes drinking water are collected weekly.

description of the types of samples collected at the various locations is given in the referenced legend.

Environmental Airborne Radioactivity

Environmental airborne radioactivity is measured at three locations on the Knolls Site, four locations on the West Milton Site, and at the General Electric Company Research Laboratory approximately one mile west of the Knolls Site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The average results of the airborne radioactivity analysis are given in table 1.

Measurements of airborne radioactivity are made at least 48 hours after collection to allow for the decay of naturally-occurring short half-life radionuclides.

TABLE 1.—GROSS BETA AIRBORNE RADIOACTIVITY

[Average concentrations in $\mu\mu c/m^3$]

Period 1960	Knolls site	West Milton site	Off-site
Third quarter	0.06	0.19	0.06
Fourth quarter	0.06	0.13	0.03
1960 summary	0.11	0.17	0.12

Liquid Radioactive Waste

Knolls Site

At the Knolls Site, all potential sources of liquid radioactive wastes are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated through the control and monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent. A daily continuous proportional sample of the Knolls Site combined sewer effluent is taken at the point of discharge to the Mohawk River. Analyses of weekly composite samples are made for radiochemical and toxic chemical content, and these analyses show that strontium-90 is the principal component which has to be considered in hazard control.

Mohawk River water is sampled at locations upstream and downstream from the Knolls Site. Sampling locations are at the General Electric Company Powerhouse eight miles upstream from the Knolls Site; at the point of discharge to the Mohawk River from the Knolls Site, at the Vischer Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station approximately 13 miles downstream. Tables 2 and 3 summarize the radionuclide content of the Knolls Site waste effluent, the amount dis-

TABLE 2.—RADIONUCLIDE CONTENT OF THE KNOLLS SITE WASTE EFFLUENT

Radionuclide	Third quarter	Fourth quarter	1960 summary
	Average concentration ($\mu\mu c$/liter)	Average concentration ($\mu\mu c$/liter)	Average concentration ($\mu\mu c$/liter)
Ce^{144} and Pr^{144}	1000	310	2300
Sr^{89}	590	230	1700
Sr^{90}	440	60	910
Cs^{137}	530	140	1800
Ru^{106}	----------	100	230
Zr^{95}	----------	150	380
I^{131}	----------	----------	76

TABLE 3.—GROSS BETA RADIOACTIVITY DISCHARGED AND DETECTED IN THE MOHAWK RIVER

[Average concentrations in μμc/liter]

1960 Period	Total waste discharged (millicuries)	Average concentration discharged	Upstream	Downstream			Precipitation at Knolls Site
			GE powerhouse	Vischer Ferry	Cohoes		
					Raw	Treated	
Third quarter	296	2,500	9	10	9	4	24
Fourth quarter	108	1,000	3	2	2	1	120
1960 summary	3,125	7,600	5	5	8	4	74

TABLE 4.—GROSS BETA DISCHARGED AND DETECTED IN GLOWEGEE CREEK

1960 Period	Total waste discharged (millicuries)	Average concentration discharged (μμc/liter)	Average concentration in creek		Precipitation (μμc/liter)
			Upstream (μμc/liter)	Downstream (μμc/liter)	
Third quarter	4.36	290	7	4	69
Fourth quarter	1.93	140	11	9	44
1960 summary	8.20	140	13	9	94

charged, and the gross beta concentrations detected in the Mohawk River water.

The Knolls Site effluent is monitored continuously for alpha radioactivity. Since the quarterly discharge rate is less than one percent of the most restrictive environmental limit for alpha (Pu^{239}), the data are not reported.

West Milton Site

The Glowegee Creek does not have a reliable dilution potential and therefore the radioactivity levels in the liquid waste from the West Milton Site are operationally controlled and diluted before release to the creek. Samples of the Glowegee Creek water are taken once a week at two locations, 150 feet above and 2,640 feet below the point where the West Milton Site effluent enters the creek. Table 4 presents the quantities of radioactivity discharged into and detected in Glowegee Creek samples. Since no alpha radioactivity is discharged from the West Milton Site, alpha analyses are not performed.

Precipitation has a variable effect upon the Glowegee Creek samples. This effect is dependent upon the amount of rainfall, creek flow and the period of sampling relative to the period of precipitation. The results of precipitation sampling are also found in table 4.

Soil samples are collected bi-weekly at two locations, one on the Knolls Site and the other off-site. The off-site location is approximately two miles northeast of the Knolls Site. The sampling location was selected after a four-year study of wind directions. This station was upwind of the Knolls Site exhaust stacks 98 percent of the time in the period tested. The results of the gross beta radioactivity analyses of the soil samples are in table 5.

TABLE 5.—GROSS BETA RADIOACTIVITY IN SOIL SAMPLES

[Average concentrations in μμc/gm]

1960 Period	Knolls Site	Off-site
Third quarter	20	20
Fourth quarter	22	22
Annual summary	19	21

General Conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory at both the Knolls Site and the West Milton Sites, it is concluded that the operations at these installations did not adversely affect the radioactivity levels of the local environment. In addition, the results of the environmental survey indicate that the levels of radioactivity detected at all times were within the standards established by the U. S. Atomic Energy Commission based on the recommendations of the National Committee on Radiological Protection and Measurements.

S1C Prototype Reactor Facility

Combustion Engineering, Inc.
Windsor, Connecticut

—Issued June 1961

Environmental levels of radioactivity at the S1C Prototype Reactor Facility have been reported in *Radiological Health Data,* Volume I, Number 9, and Volume II, Number 1. The following report presents a summary of the data for the third and fourth quarters of 1960.

The S1C Prototype is a land based nuclear submarine power plant facility. This facility is operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. at Windsor, Connecticut. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in operation of naval reactor power plants. Reactor power operations at the S1C prototype facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C Prototype operations consists mainly of water. Small quantities of airborne particulate in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially all of the radioactive waste originate from the activation of minute amounts of impurities in corrosion products in the circulating water used as a reactor coolant. Small quantities of gaseous waste result from the activation of minute amounts of air dissolved in the coolant water.

Airborne Waste Effluent

Ventilation air from the submarine hull and the supporting facility at the prototype site may, at times, contain small amounts of airborne radioactive particulate or gaseous activities. This ventilation air is discharged to the environment at below permissible levels through an exhaust stack. The ventilation air is continuously monitored for radioactivity by particulate and gaseous counters which control the discharge of ventilation air. Alarms are sounded if the concentration approaches permissible limits. When these limits are exceeded, the exhaust air is discharged through a high efficiency filter bank or the ventilation system is completely shut down and the hull sealed. Table 1 presents the results of the airborne waste effluent monitoring at the exhaust stacks. Table 2 shows gross beta-gamma concentrations in air samples taken on-site downwind at the point of release.

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, S1C PROTOTYPE SITE

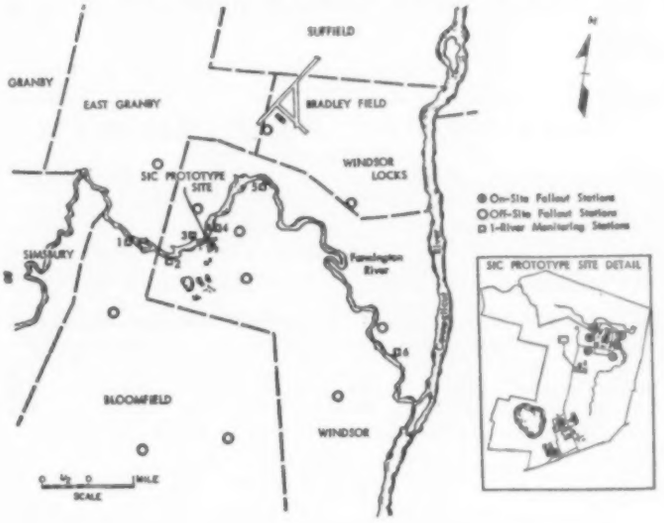


TABLE 1.—GROSS BETA-GAMMA CONCENTRATIONS IN EXHAUST STACK EFFLUENTS

[Average concentrations in $\mu\mu c/m^3$]

1960 Period	Gross beta-gamma
Third quarter	46
Fourth quarter	68
Annual summary	56

TABLE 2.—GROSS BETA-GAMMA CONCENTRATIONS ON SITE DOWNWIND OF RELEASE POINT

[Average concentrations in $\mu\mu c/m^3$]

1960 Period	Gross beta-gamma
First quarter [1]	7.4
Second quarter [1]	25
Third quarter	22
Fourth quarter	25
Annual summary	20
Pre-operational (fourth quarter 1959)	62

[1] Not previously reported.

Radioactive fallout is collected on a weekly basis at six locations around the site and analyzed for gross radioactivity. Off-site fallout collections in neighboring towns are also made and analyzed for gross radioactivity. A comparison is then made between the on-site and off-site stations. Locations of the various fallout stations are shown in figure 1. The on-site and off-site fallout data are presented in table 3.

TABLE 3.—GROSS BETA CONCENTRATIONS IN FALLOUT

[Average Concentrations in mc/mi²/month]

1960 period	On-site		Off-site	
	Number of samples	Gross beta	Number of samples	Gross beta
Third quarter	71	1.28	117	1.11
Fourth quarter	48	0.39	74	0.31
Annual summary	231	1.85	325	1.63

Preoperational averages from October to December 1959 showed an average of 2.00 mc/mi²/month for prototype site fallout stations and 2.04 mc/mi²/month for the fallout stations located in neighboring towns. From table 3, it can be seen that the fallout on-site is essentially the same and is at a very low level. This fallout has therefore been attributed to residual activity from weapons tests rather than from S1C Prototype operations.

Farmington River Monitoring

Liquid wastes are collected in 5,000 gallon retention tanks. When a tank is full, it is sampled and analyzed for its radioactivity content. If the activity is below the allowable discharge limit, the tank contents are released into the industrial waste system. If the limit is exceeded the contents are diluted below acceptable limits in a 25,000 gallon dilution tank and then released. Table 4 is a summary of the gross radioactivity released to the Farmington River.

TABLE 4.—SUMMARY OF GROSS BETA-GAMMA RADIOACTIVITY RELEASED TO THE FARMINGTON RIVER

1960 period	Total for period (millicuries)	Average concentration released (μμc/liter)
Third quarter	2.94	1,500
Fourth quarter	4.70	2,600
Annual summary	7.78	800

The Farmington River is sampled monthly at various locations as shown in figure 1 for determination of alpha and beta-gamma activity in river water and mud. The results of this sampling are presented in tables 5 and 6.

TABLE 5.—GROSS RADIOACTIVITY OF WATER SAMPLES FROM THE FARMINGTON RIVER

Location number (see figure 1)	Third quarter 1960				Fourth quarter 1960				Annual summary 1960	
	Number of samples	Alpha (μμc/liter)	Beta-gamma (μμc/liter)	Uranium (ppm)	Number of samples	Alpha (μμc/liter)	Beta-gamma (μμc/liter)	Uranium (ppm)	Number of samples	Beta-gamma (μμc/liter)
Upstream										
1	[a] 4	68	7.1	0.003	3	206	16.5	0.001	20	30.9
2	4	172	13.9	0.002	2	294	1.0	0.003		
Outlet										
3	4	315	16.5	0.006	2	339	2.5	ND	9	6.1
Downstream										
4	4	114	4.9	0.002	1	149	9.0			
5	4	84	4.6	[b] ND	3	276	49.5	0.003	30	8.9
6	4	188	4.9	ND	3	105	15.0	ND		

[a] Includes results for June, not reported previously.
[b] ND—Non-detectable.

TABLE 6.—GROSS RADIOACTIVITY OF MUD SAMPLES FROM THE FARMINGTON RIVER

Location number (see figure 1)	Third quarter 1960				Fourth quarter 1960				Annual summary	
	Number of samples [1]	Alpha ($\mu\mu$c/gm)	Beta-gamma ($\mu\mu$c/gm)	Uranium (ppm)	Number of samples	Alpha ($\mu\mu$c/gm)	Beta-gamma ($\mu\mu$c/gm)	Uranium (ppm)	Number of samples	Beta-gamma ($\mu\mu$c/gm)
Upstream 1	2	31.7	0.92	2.39	3	1.8	3.66	0.58	16	2.5
2	2	0.9	0.13	0.40	2	4.5	4.70	3.23		
Outlet 3	2	3.2	0.86	2.33	2	2.1	5.49	5.29	7	3.0
Downstream 4	2	1.0	0.95	0.57	2	11.8	4.36	1.14	15	2.8
5	0				0					
6	2	0.6	3.11	0.55	3	1.9	2.14	0.56		

[1] Includes results for June, not reported previously.

General Conclusions

The data for the year show that there is no significant contribution of radioactivity to the environment from the S1C Prototype Reactor Facility. Furthermore, the radioactivity discharged to the environment under controlled conditions from the S1C Prototype were in compliance with the recommendations of the National Committee on Radiation Protection and the radiation protection standards established by the Federal Radiation Council.

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